

ATLAS OF RADIATION BUDGET MEASUREMENTS FROM SATELLITES (1962-1970)

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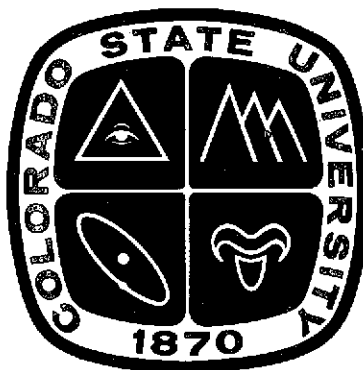
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BY

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Atmospheric Science

PAPER NO.

231



**DEPARTMENT OF ATMOSPHERIC SCIENCE
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December, 1974

Preface

Radiation budget measurements taken at the top of an atmospheric column will continue to grow in importance for monitoring and predicting changes within the column. As atmosphere and ocean circulation models grow in sophistication such measurements may certainly be incorporated as initial or update conditions. Already the measurements have contributed to a global radiation budget climatology which verified or corrected previous estimates, pointed out significant changes within a year and year-to-year in the radiation budget, and/or specified net energy transports by both the atmosphere and oceans.

The existing data have contributed to the design of new radiation budget measurements systems. In the mid-seventies, data from the Earth Radiation Budget experiment on the Nimbus F and G satellites will augment these earlier data. A conceptual study, including engineering design and scientific requirements, is now underway to define the radiation budget measurement system of the 1980's and beyond.

Abstract

Radiation budget data measured at the top of the atmosphere by earth-orbiting satellites are presented for various time periods in the years 1962 through 1970. They appear in the form of contoured maps which were derived from 5 seasonal and 25 monthly and semi-monthly data sets. Data published by other authors within this time period are not duplicated but are referenced for the reader's benefit. Part I contains documentation and contoured maps. Part II contains data tabulation at each 10 degrees latitude and longitude: it appears on microfiche inside the cover.

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1.0 INTRODUCTION

The purpose of this atlas is to make available, for research purposes, an extensive set of earth-atmosphere radiation budget measurements taken from earth orbiting satellites. The data are values of:

1) planetary albedo; 2) infrared radiant exitance; 3) absorbed solar energy; and 4) net radiation balance. This is the most complete collection of data available to date¹. The data begin with the TIROS 4 series in spring 1962 and extend through the Nimbus 3 series, February 1970. Computer contoured maps appear in this first part of a two part publication. Tabulation of these data at each 10 degrees latitude and longitude comprise Part II on microfiche within the cover.

2.0 SATELLITE DATA SOURCES

There are 30 basic data sets, i.e., 25 months and semi-months and 5 seasons. These sets have been combined to form additional season and mean season, annual and mean annual sets to give a total of 42 data sets. Table 1 summarizes the satellite radiation budget data temporal distribution during the 9 year period, and combinations used to form averages.

¹A few exceptions should be noted. All are in published form and therefore are not duplicated in this atlas. Winston and Taylor (1967) present maps of albedo and infrared radiant exitance from the TIROS-IV and TIROS-VII experiments, some of which duplicate portions of the present atlas. Raschke (1968) provides Nimbus-2 data maps for four 15-day periods in addition to the Nimbus-2 data included in this atlas. Other data, such as the infrared exitance maps of Boldyrev and Vetlov (1970) and Winston et al. (1972) are not included because they represent only one component of the earth's radiation budget, not being matched with concurrent measurements of planetary albedo.

TABLE 1: AVAILABLE RADIATION BUDGET DATA FROM U.S. SATELLITES: TIROS 4 (T4), TIROS 7 (T7), EXPERIMENTAL (EX), NIMBUS 2 (N2), NIMBUS 3 (N3), ESSA 3 (E3), ESSA 5 (E5), ESSA 7 (E7), ESSA 9 (E9), ITOS 1 (I1), AND NOAA 1 (NO1)
DATA NOT INCLUDED IN THIS ATLAS DENOTED BY BRACKETS [].

Months	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	No.
JAN				EX(1030)		[E3]		[E7]	[E9],N3(1130)		2
FEB				EX				[E7]	[E9]	[NO1]	1
MAR				EX				[E7]	[E9], [I1]	[NO1]	1
APR				EX(0840)				[E7],N3(1130)	[I1]		2
MAY				EX(0855)	[N2]	[E5]		*N3	[I1]	[NO1]	2
JUN				EX(0910)	[N2]	[E5]		[E9],N3(1130)	[I1]		2
JUL			EX(0830)	EX(0925)	N2(1130)	[E5]		[E9],N3(1130)			4
AUG			*EX	EX(0940)		[E5]		[E9],N3(1130)			3
SEP			EX	*EX(1000)		[E5]		[E9]			2
OCT			EX	EX(1020)			[E7]	[E9],N3(1130)			3
NOV			EX	[EX]			[E7]	[E9]			1
DEC			EX(1030)		E3(1340)		[E7]	[E9]			2
Seasons											
DJF			T7	EX		E3			N3		4
MAM	T4		T7	EX				N3			4
JJA		T7	EX	EX	N2			N3			5
SON		T7	EX	EX				N3			4

NOTE: The DJF Season is assigned the year of the respective January
* not included in season average.

A certain amount of information about the satellite experiments is necessary to give the data scientific utility. All users are strongly encouraged to refer to the following for background information: Vonder Haar and Suomi (1971); Vonder Haar (1972); and Raschke et al., (1973). In addition, the following remarks concern spatial and temporal sampling biases in the 30 basic sets which were not accounted for in data reduction.

2.1 Spatial Sampling Bias

There are areas on some maps where data do not appear because of various sampling problems. Satellite measurements poleward of 62.5° latitude do not exist with the TIROS series of satellites due to a low inclination angle of the orbit (Bandeem et al., 1965). The January 21 to February 3, 1970 Nimbus 3 daytime samples (shown in Table 1 as January, 1970) are missing from eastern Asia to south of Australia. Night time infrared exitance samples are also missing over a large area of western Europe, western Africa and the South Atlantic. For a more detailed account and analysis of the Nimbus 3 data see Raschke et al. (1973).

2.2 Temporal Sampling Bias

A major temporal sampling deficiency is the local time bias in the data acquired from sun-synchronous satellites. These satellites sample at the same local sun time (or nearly so) each day. Thus, albedo and radiant exitance measurements are representative at that time but do not account for diurnal changes in cloudiness and radiating temperatures.

The TIROS series of measurements do not contain this bias since their orbital precession allowed sampling at all local times over a period of less than 3 months (76 days for TIROS 7). The numbers in parentheses in Table 1 indicate the nominal local sun time of the equatorial crossing during the daylight passes only. Vonder Haar and Hanson (see Vonder Haar, 1968 or Vonder Haar, 1972) did a preliminary study of the diurnal bias in the satellite radiation budget data.

3.0 DISCUSSION OF THE ATLAS DATA

Each radiation budget data set is composed of the fundamental radiation budget components, i.e., planetary albedo, absorbed shortwave radiation, longwave exitance and net radiation. The relationships between the components are represented as:

$$RN = (1.0-A)I - RL$$

or

$$RN = RA - RL$$

with the notation defined as:

RN, net radiation ($\text{cal} \cdot \text{cm}^{-2} \cdot \text{min}^{-1}$)

A, Albedo

I, solar insolation at $P=0$ (Solar constant taken as $1.95 \text{ cal} \cdot \text{cm}^{-2} \cdot \text{min}^{-1}$)

RL, longwave radiant exitance ($\text{cal} \cdot \text{cm}^{-2} \cdot \text{min}^{-1}$)

RA, absorbed shortwave radiation

All components present the values at the top of an atmospheric column (pressure=0) and each is a function of latitude, longitude and time.

In addition to the four component maps of the mean season and 17 season average data there are four maps representing the deviation from

the zonal average (Vonder Haar, 1972). The values on these maps were derived mathematically as:

$$Z' = Z - \bar{Z}$$

where \bar{Z} is the average around a latitude circle; Z is the radiation budget component at each grid point; Z' is the deviation from zonal average at each grid point.

All data are gridded on a 10 degree latitude by 10 degree longitude grid and are objectively contoured on an equidistant map projection. Contour intervals of isoline values for each data set analysis are shown in Table 2. Monthly and seasonal data were combined to arrive at seasonal, annual and mean annual averages (17 season average). Missing data areas are without contours on the maps. The contoured maps appear in the order shown in the List of Contoured Maps.

TABLE 2 CONTOUR INTERVALS

Albedo	$\frac{5\%}{100\%} = 0.05$
Deviation From Zonal Average	$\frac{4\%}{100\%} = 0.04$
Longwave Radiation	$0.03 \text{ Cal cm}^{-2} \text{ min}^{-1}$
Deviation From Zonal Average	$0.02 \text{ Cal cm}^{-2} \text{ min}^{-1}$
Net Radiation	$0.04 \text{ Cal cm}^{-2} \text{ min}^{-1}$
Deviation From Zonal Average	$0.02 \text{ Cal cm}^{-2} \text{ min}^{-1}$
Absorbed Radiation	$0.05 \text{ Cal cm}^{-2} \text{ min}^{-1}$
Deviation From Zonal Average	$0.02 \text{ Cal cm}^{-2} \text{ min}^{-1}$

4.0 References

1. Bandeen, W.R., M. Halev, and I. Strange, 1965: A Radiation Climatology in the Visible and Infrared from the Tiros Meteorological Satellites. NASA TN D-2534.
2. Boldyrev, V.G., and Vetlov, I.P., 1970: Spatial and Temporal Variability of the Escaping Radiation. Meteorol. I. Gidrolog, 23-32, A 71-14637.
3. Raschke, E., 1968: The Radiation Balance of the Earth-Atmosphere System From Radiation Measurements of the Nimbus II Meteorological Satellite. NASA TN D-4589.
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6. Vonder Haar, T.H., 1972: Natural Variations of the Radiation Budget of the Earth-Atmosphere System as Measured from Satellites, Conference on Atmospheric Radiation, American Meteorological Society, Fort Collins, Colo. pp. 211-220.
7. Winston, J.S. and V.R. Taylor, 1967: Atlas of World Maps of Long-wave Radiation and Albedo for Seasons and Months Based on Measurements from TIROS IV and TIROS VII, ESSA Tech. Report NESC 43.
8. Winston, J.S., 1972: Comments on "Measurements of the Earth's Radiation Budget from Satellites During a Five-year Period: Part I. Extended Time and Space Means." Journal Atmospheric Sci., Vol 29, No. 3, pp. 598-601.

5.0 LIST OF CONTOURED MAPS

<u>Monthly and Semi-monthly</u>	<u>Plate No.</u>
July through December 1974	1
January through October 1965	25
July and December 1966	65
April, May 1-15, June, July, August 1-15, October 3-17 1969	73
January 21 to February 1970	97
 <u>Seasonal*</u>	
Spring 1962	101
Summer 1963, Fall 1963, Winter 1963-1964	105
Spring 1964, Fall 1964, Winter 1964-1965	117
Spring 1965, Fall 1964,	129
Summer 1969	137
 <u>Mean Seasonal</u>	
Spring	141
Summer	149
Fall	157
Winter	165
 <u>Mean Annual</u>	
17 seasons mean 1962-1970	173

* Seasons are defined as: Spring M-A-M, Summer J-J-A, Fall S-O-N,
Winter D-J-F.

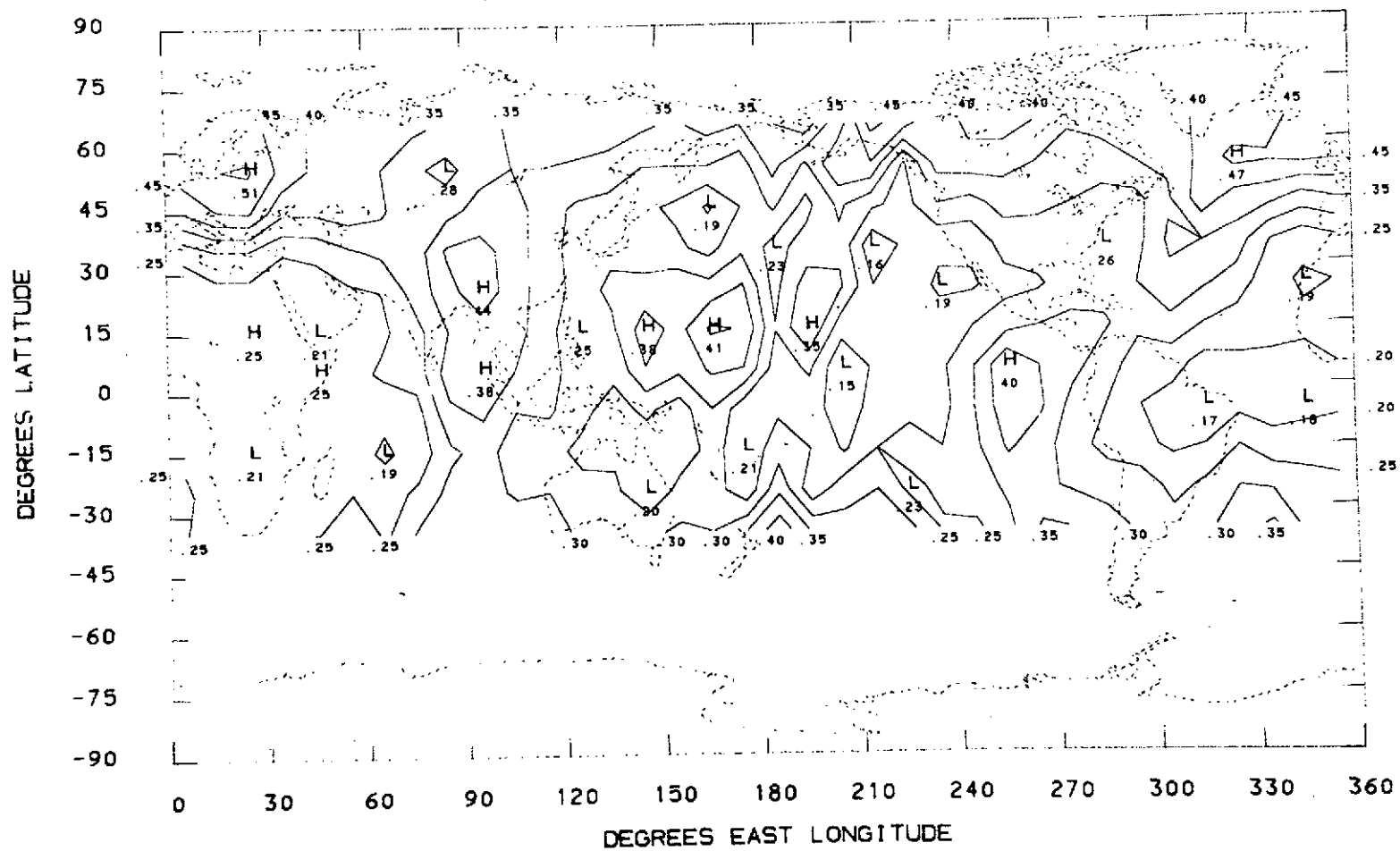
Acknowledgements

We thank the many scientists and engineers who contributed to the success of the satellite experiments. Professor Verner Suomi's personal research and dedication to the goal of measuring the earth's radiation budget inspired all of us. Mr. Jeffrey Gailiun assisted with the map layout and Ms. Lyn Koch typed the manuscript.

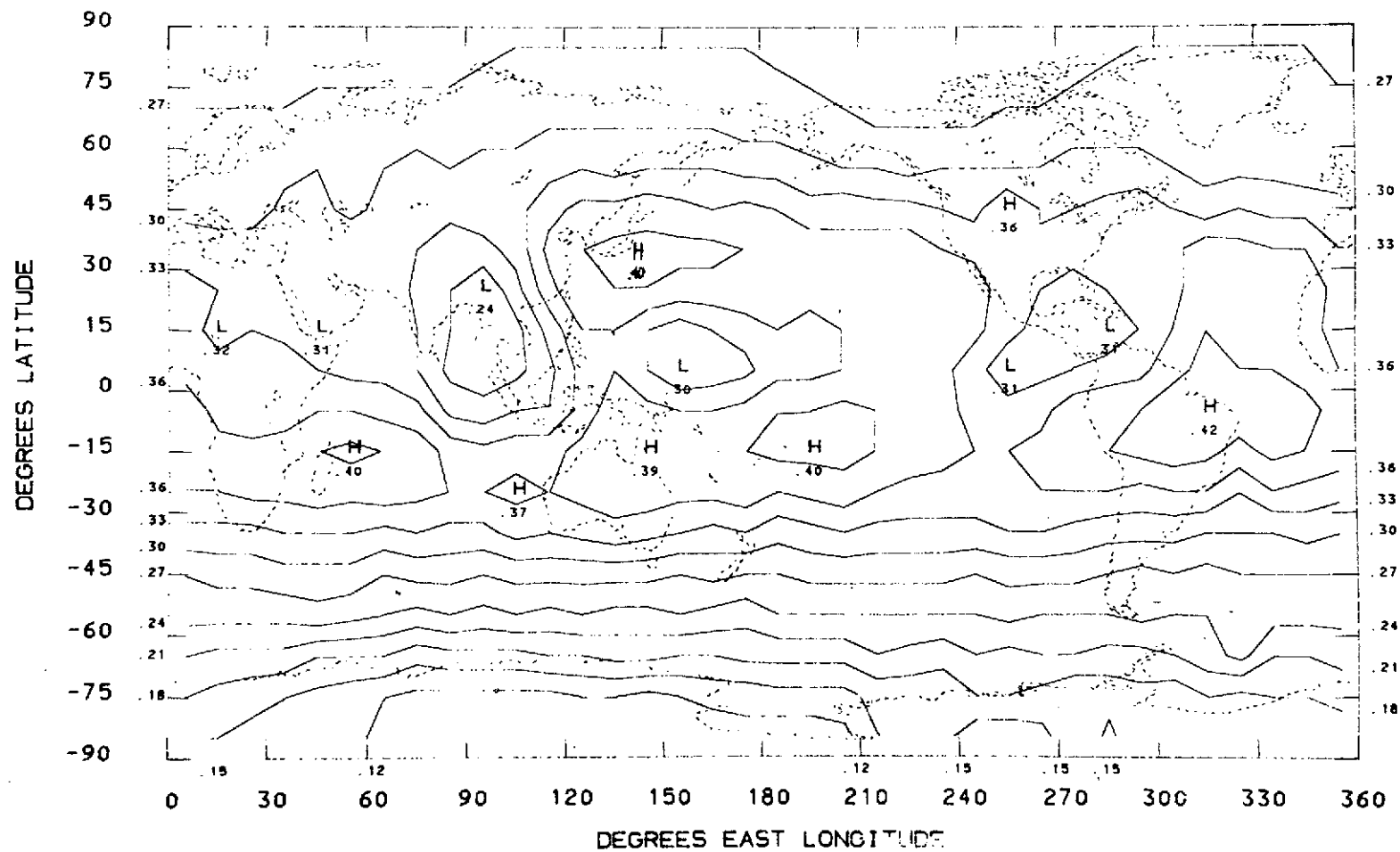
We also acknowledge the Atmospheric and Hydrospheric Applications Division of NASA Goddard Space Flight Center for sponsoring, under Grant NGR 06-002-102, the collection and preparation of this report. Additionally, the Atlas includes information from previous publications referenced in section 2.0 which were under various government sponsorships.

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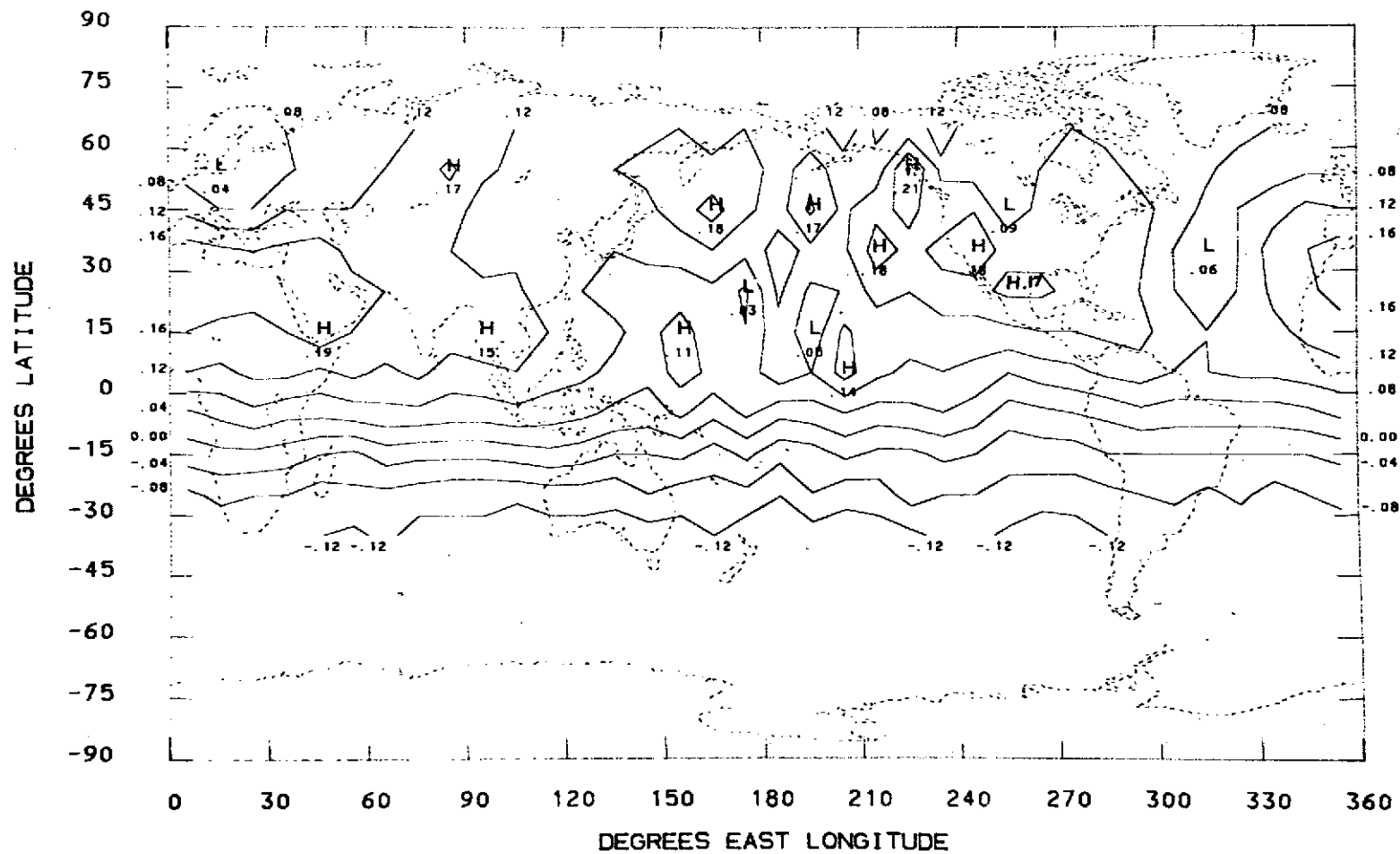
PLANETARY ALBEDO
JULY 1964



LONGWAVE RADIATION (LY/MIN)
JULY 1964

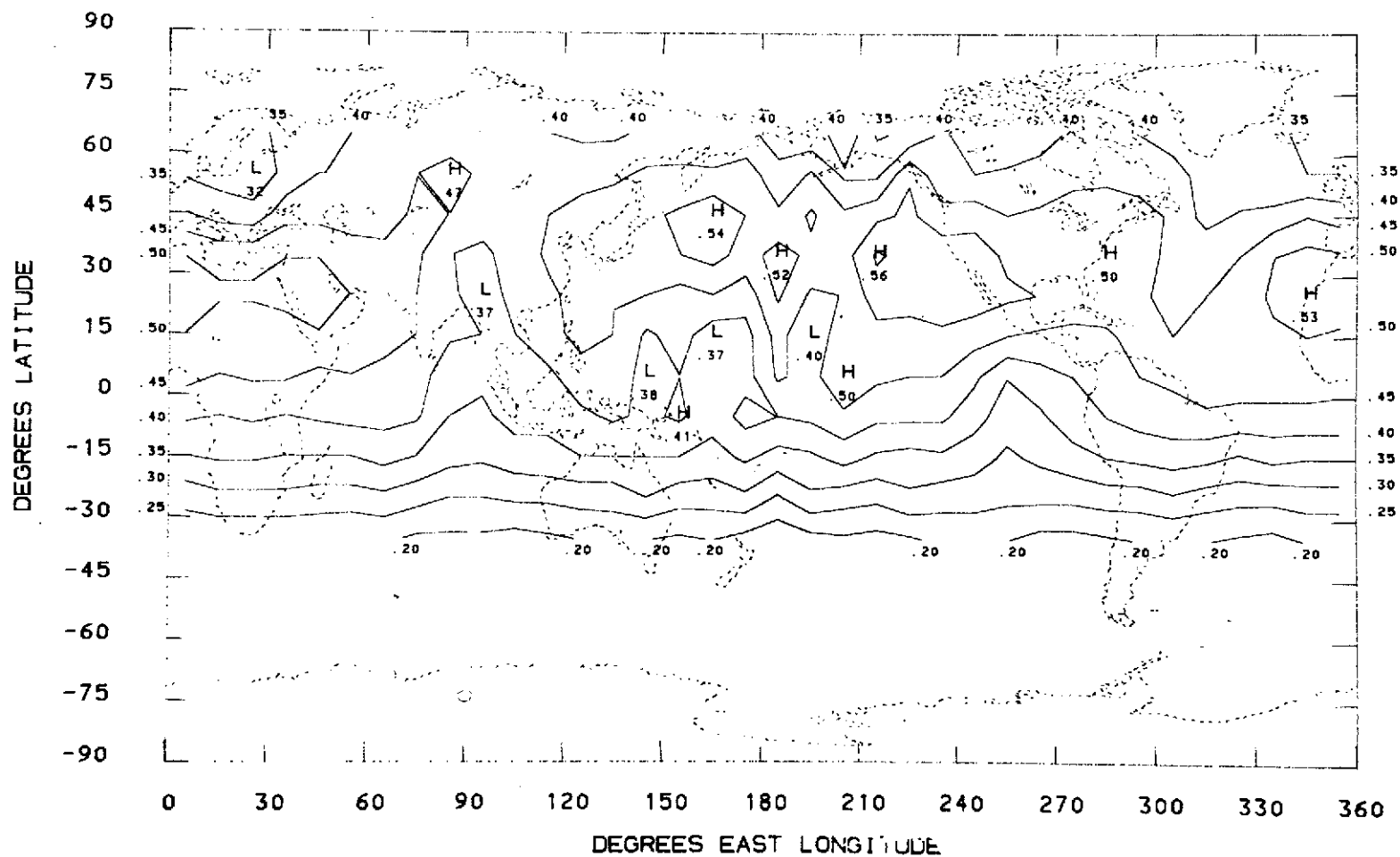


NET RADIATION (LY/MIN)
JULY 1964



ABSORBED RADIATION (LY/MIN)

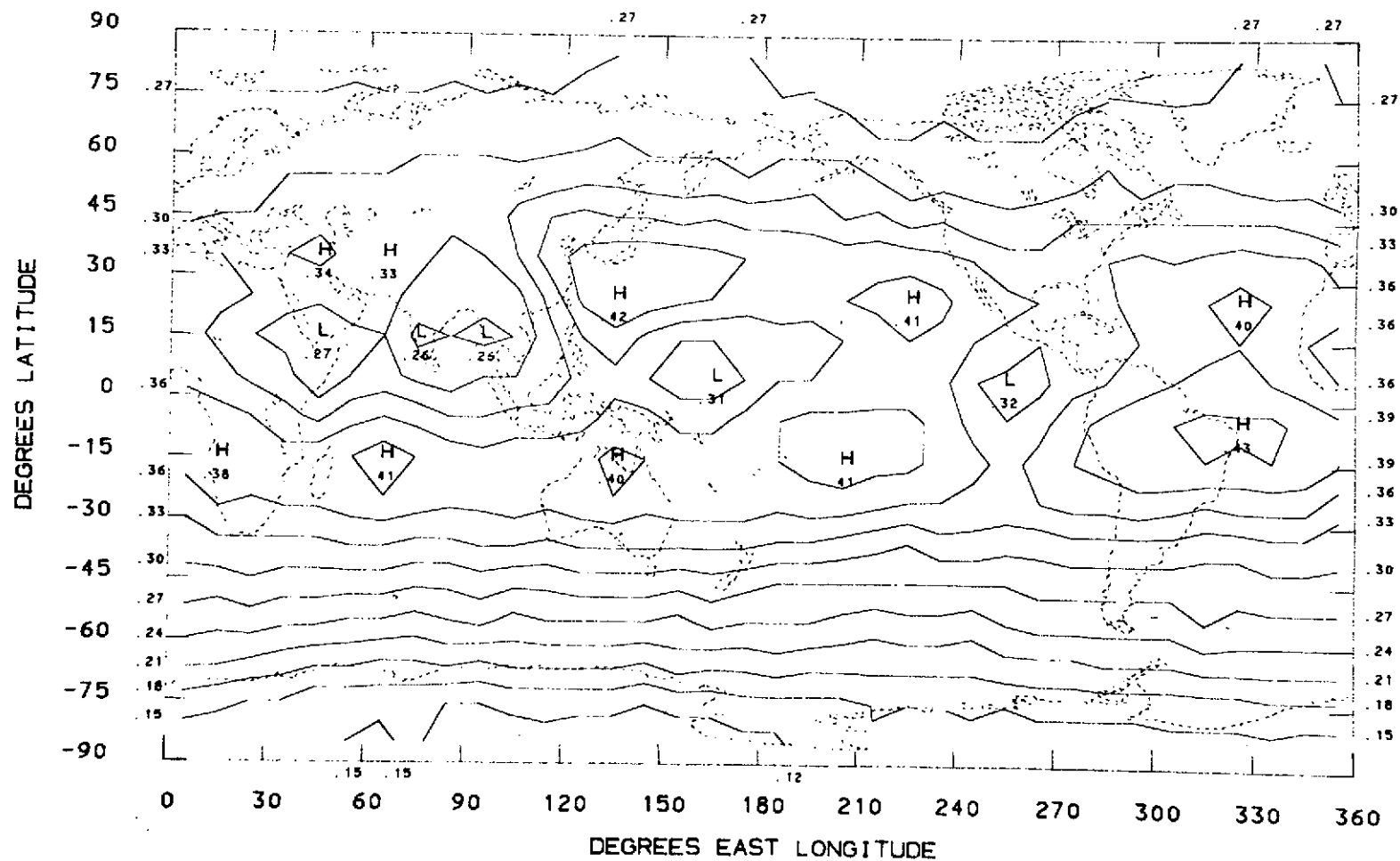
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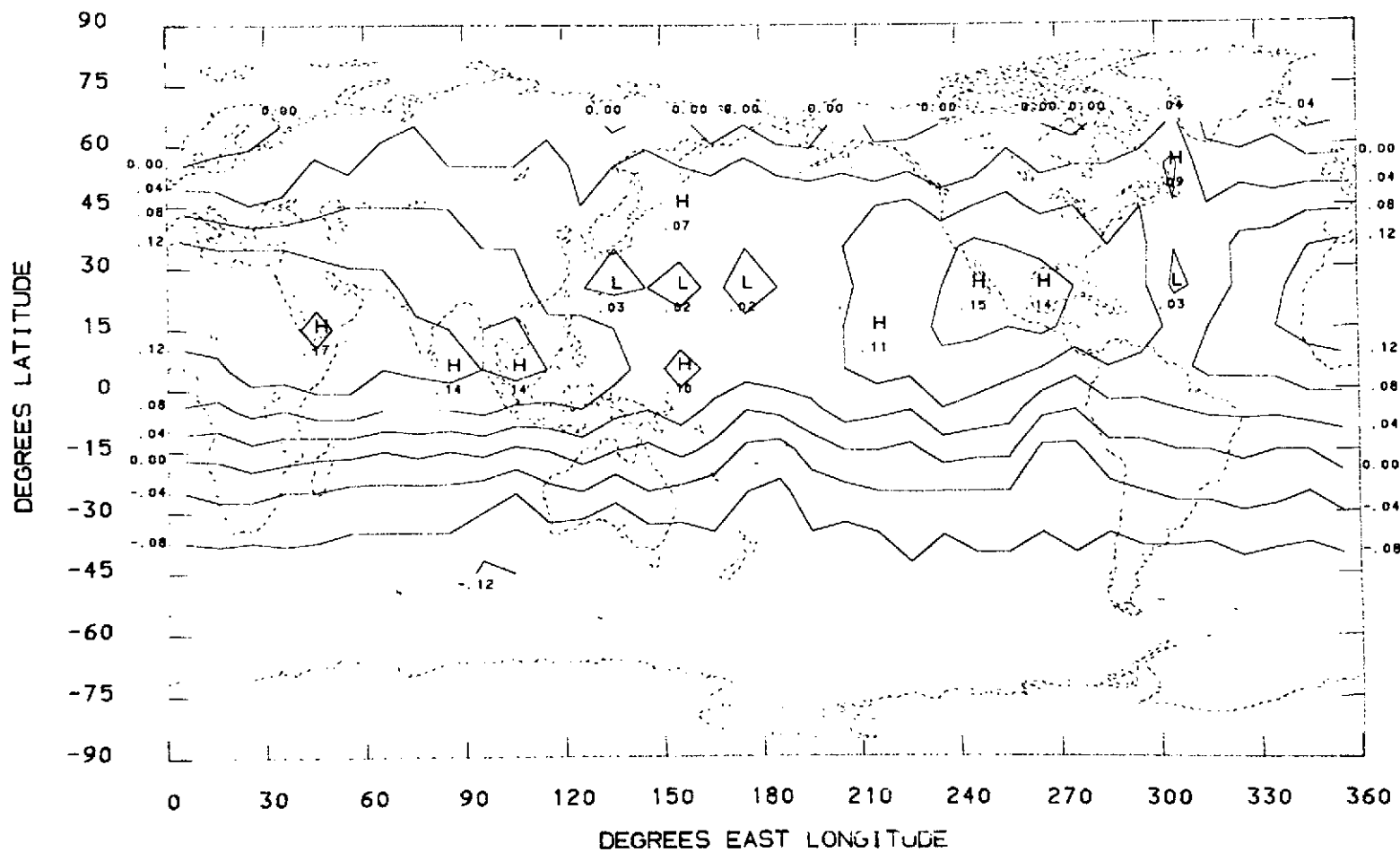


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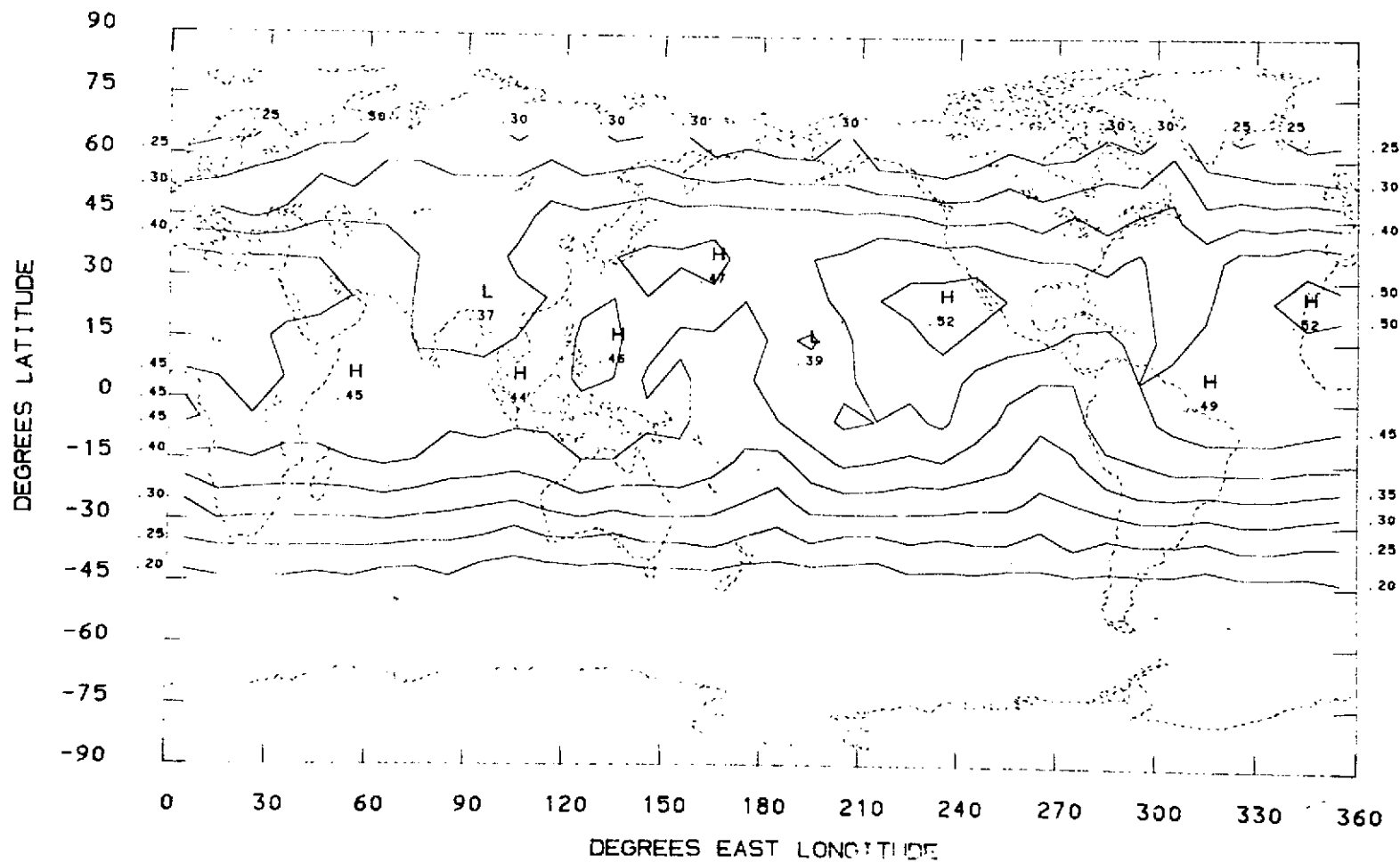


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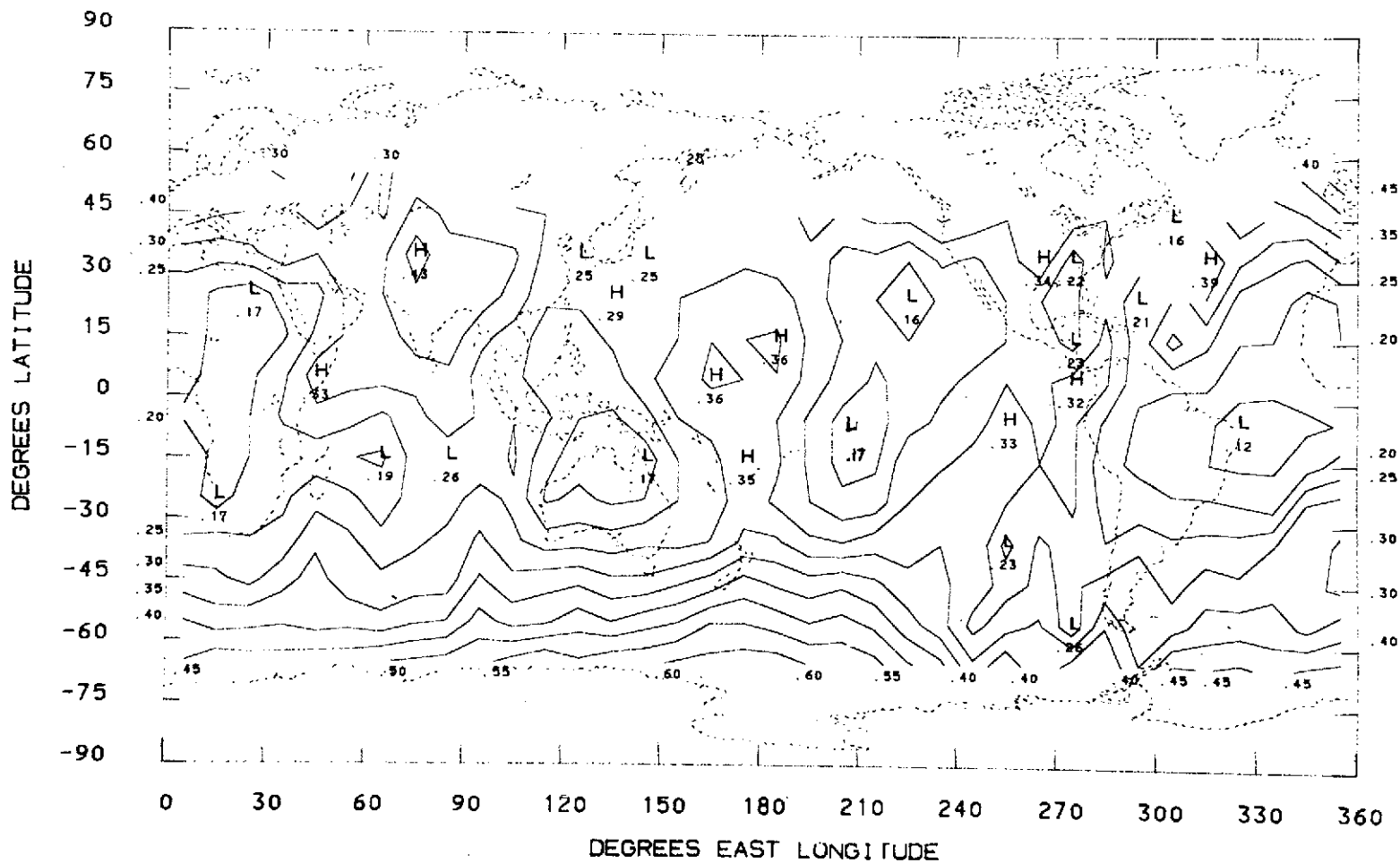


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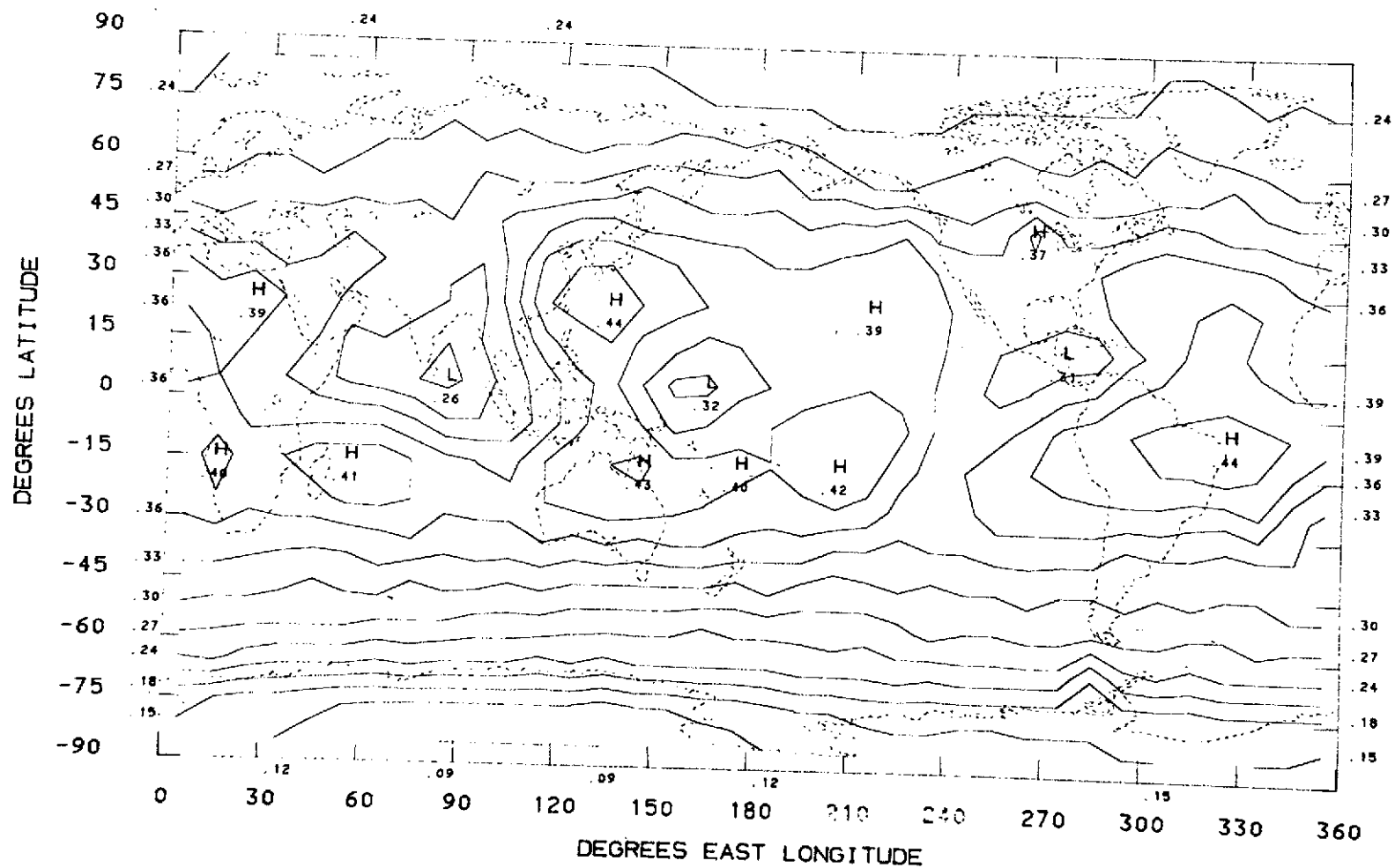


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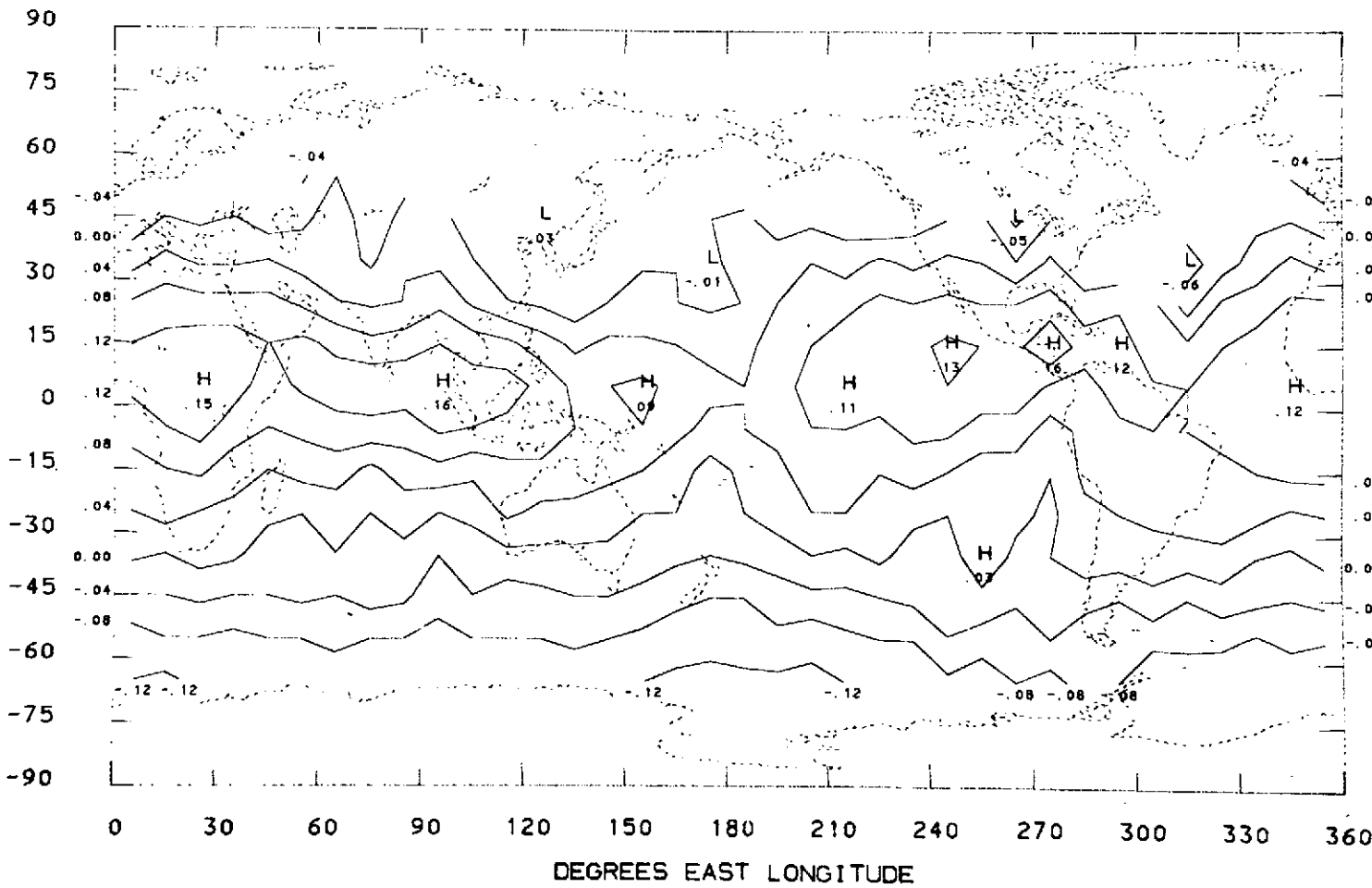
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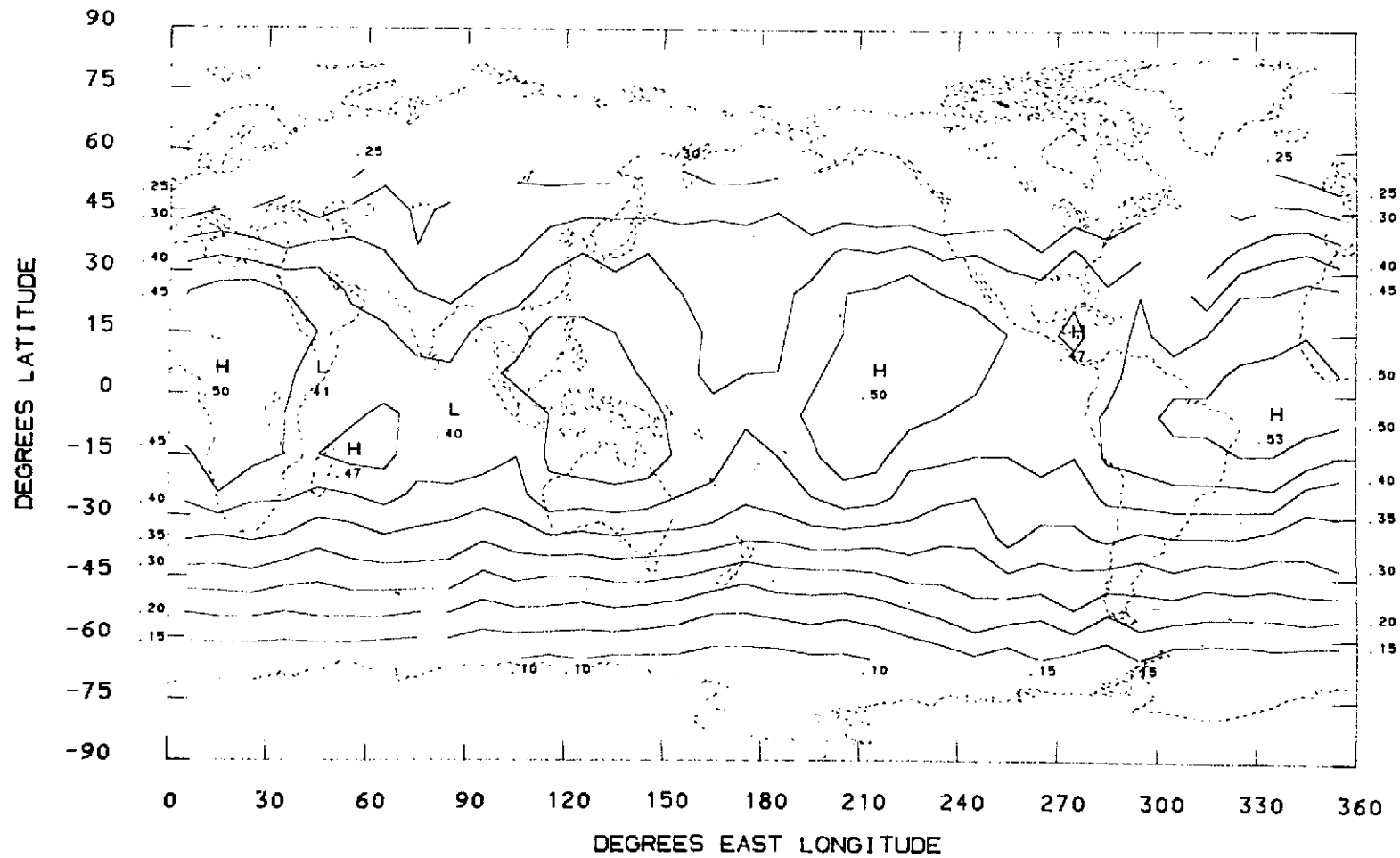
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SEPTEMBER 1964

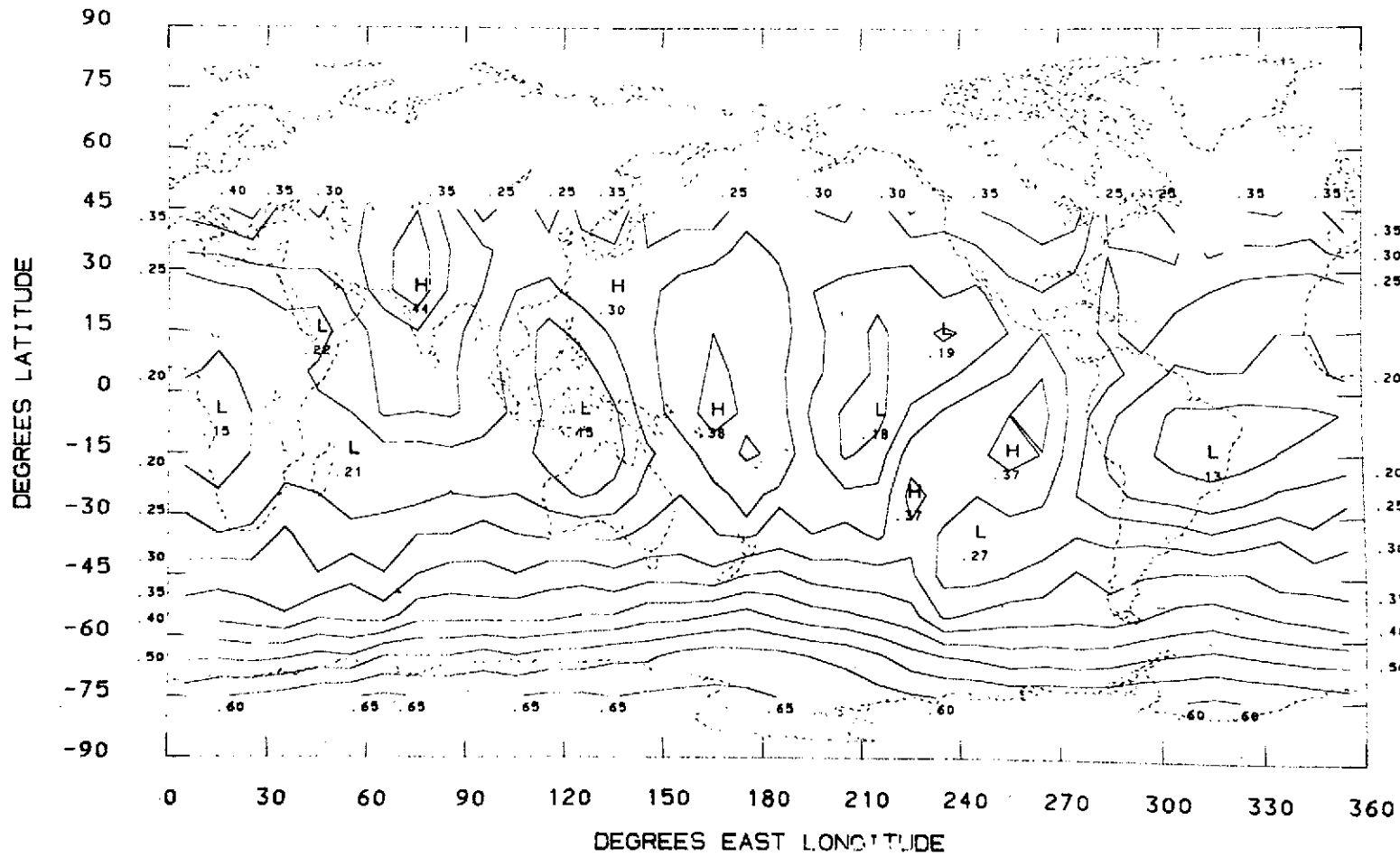


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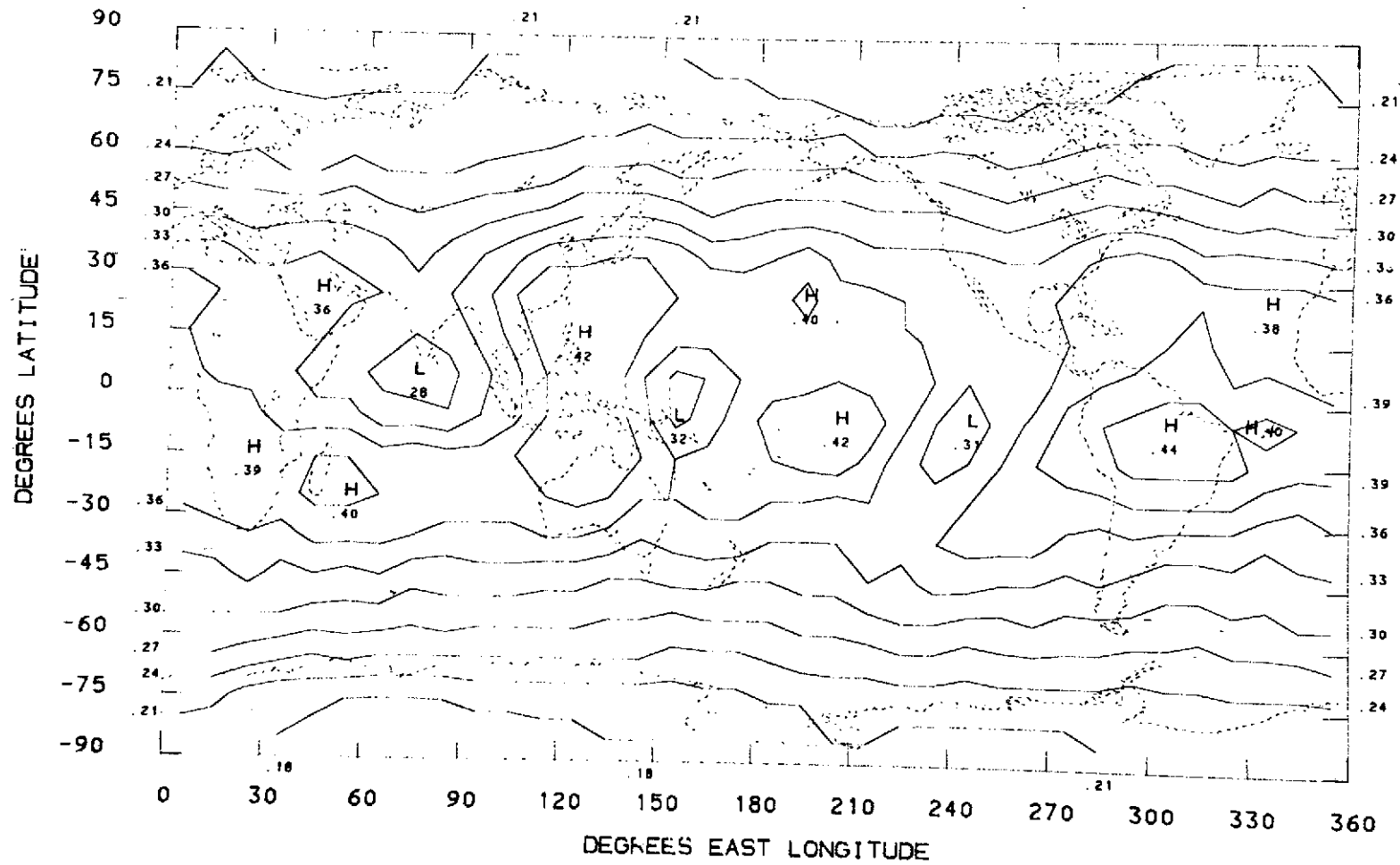


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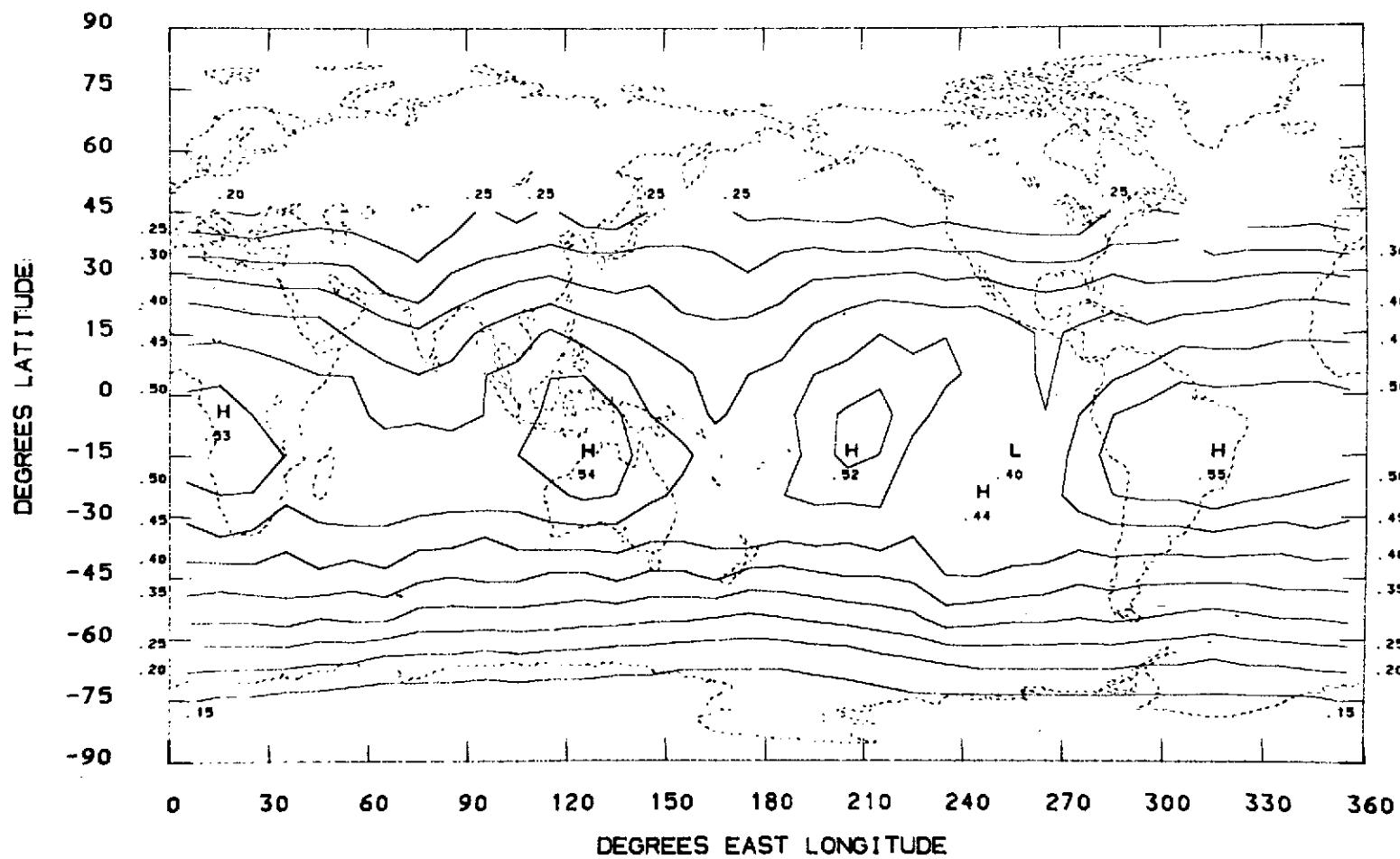
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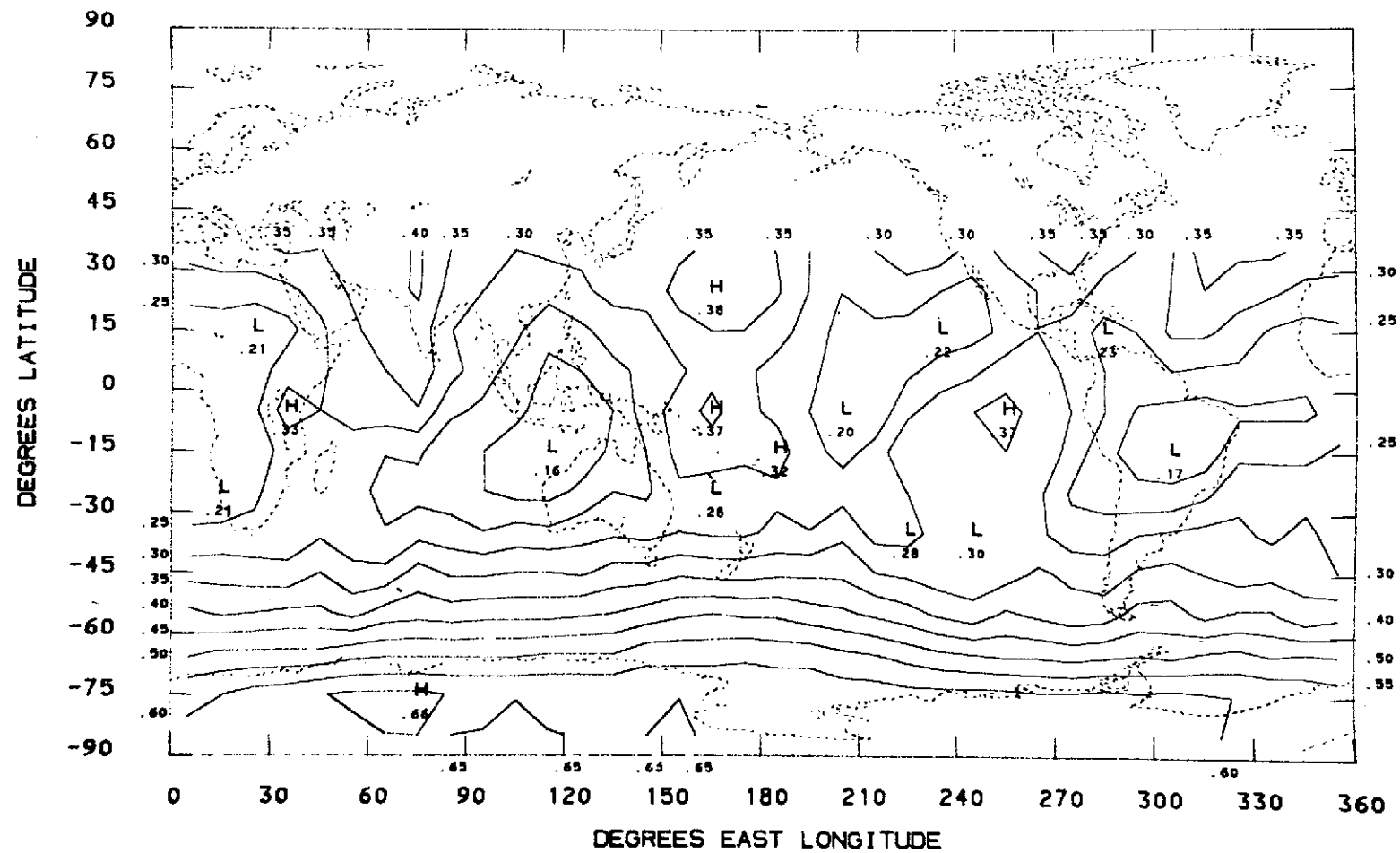
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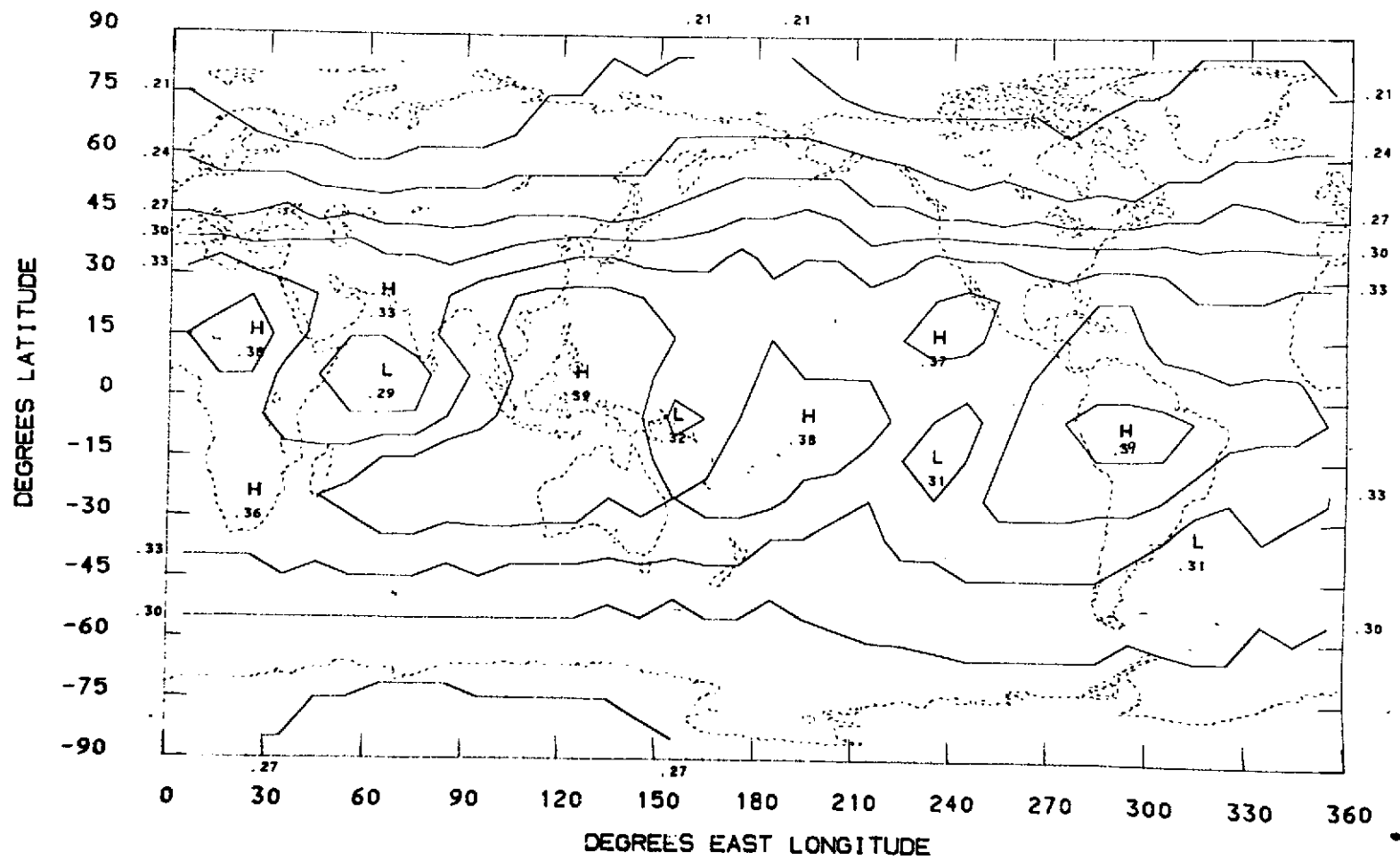
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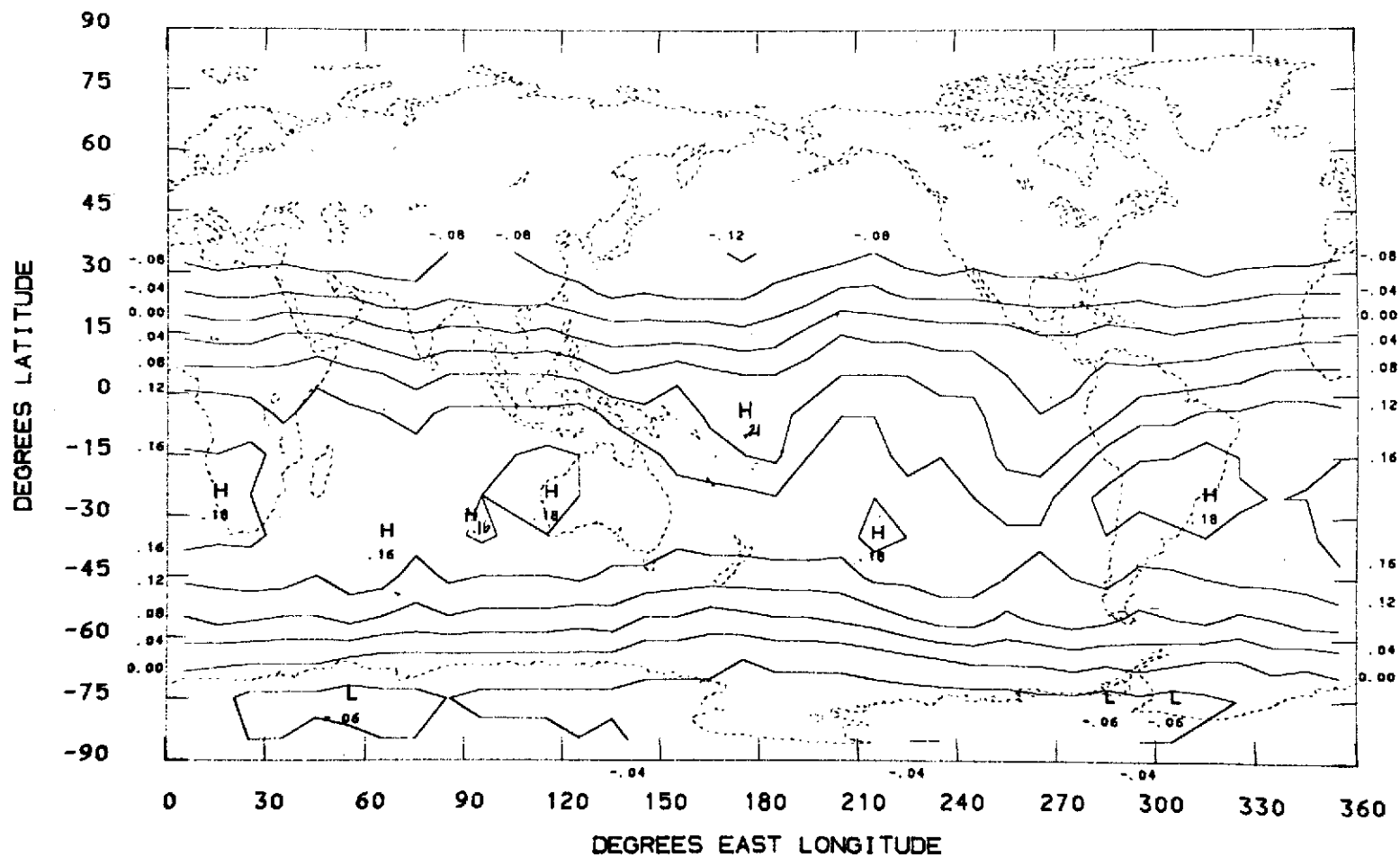
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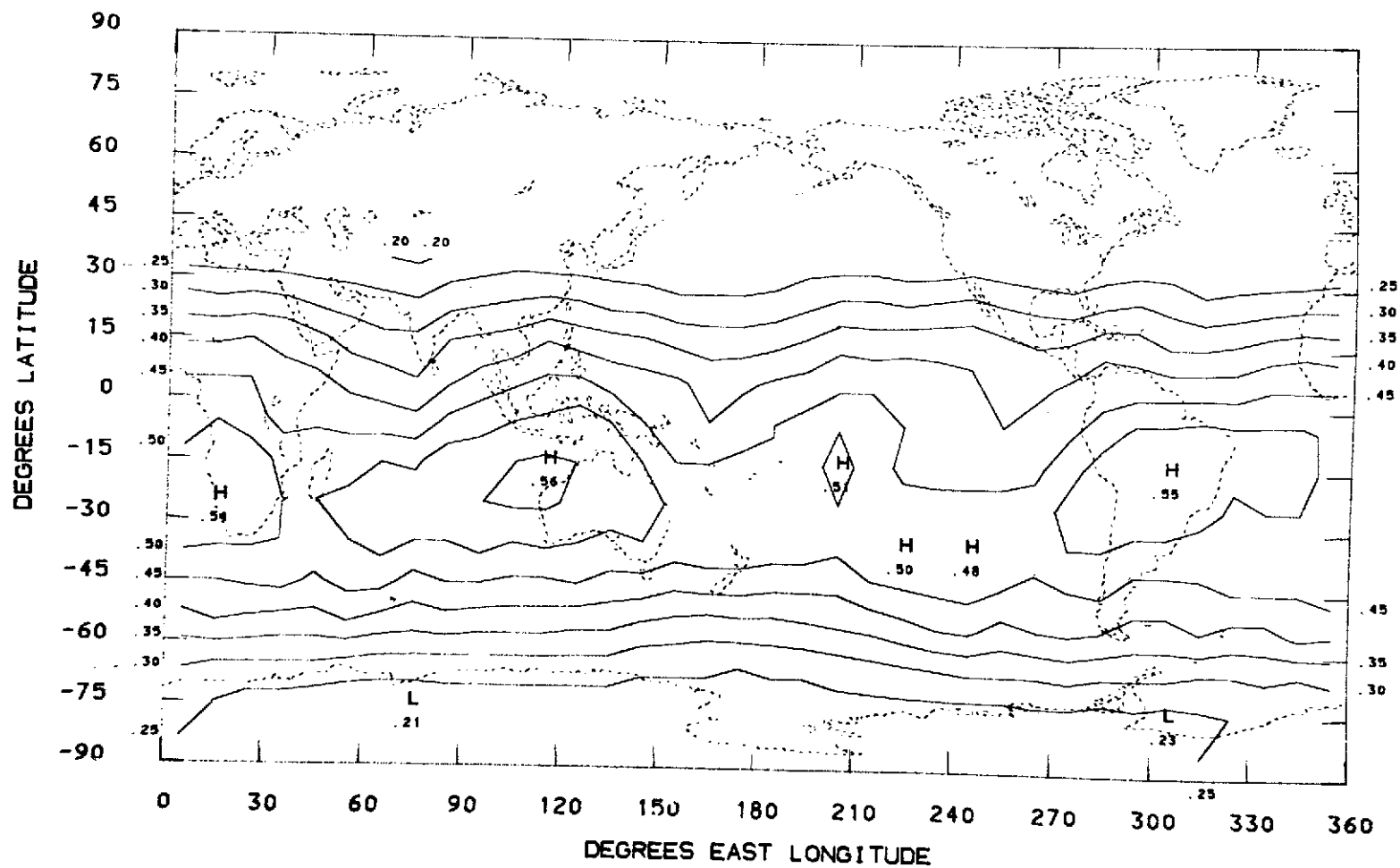
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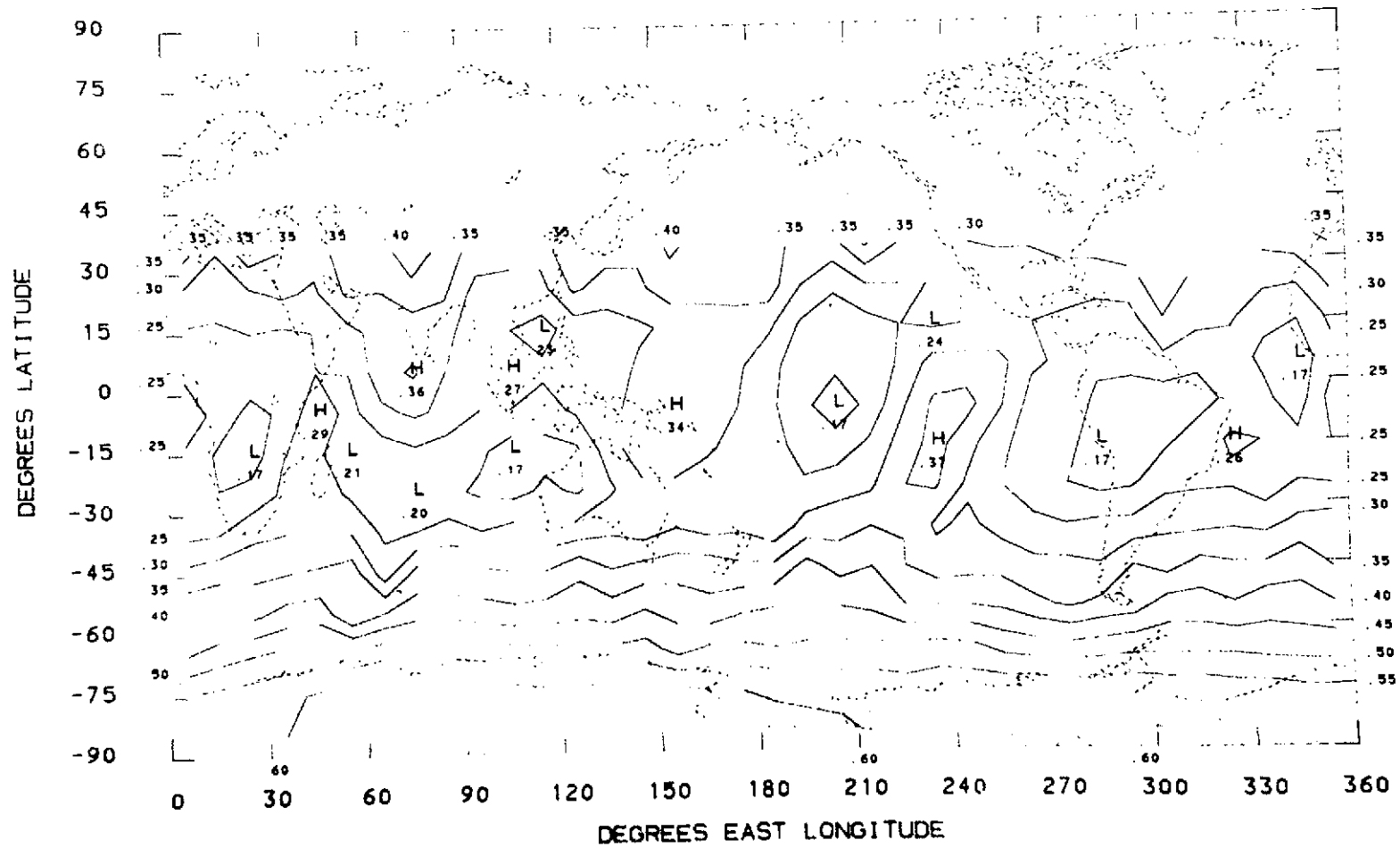
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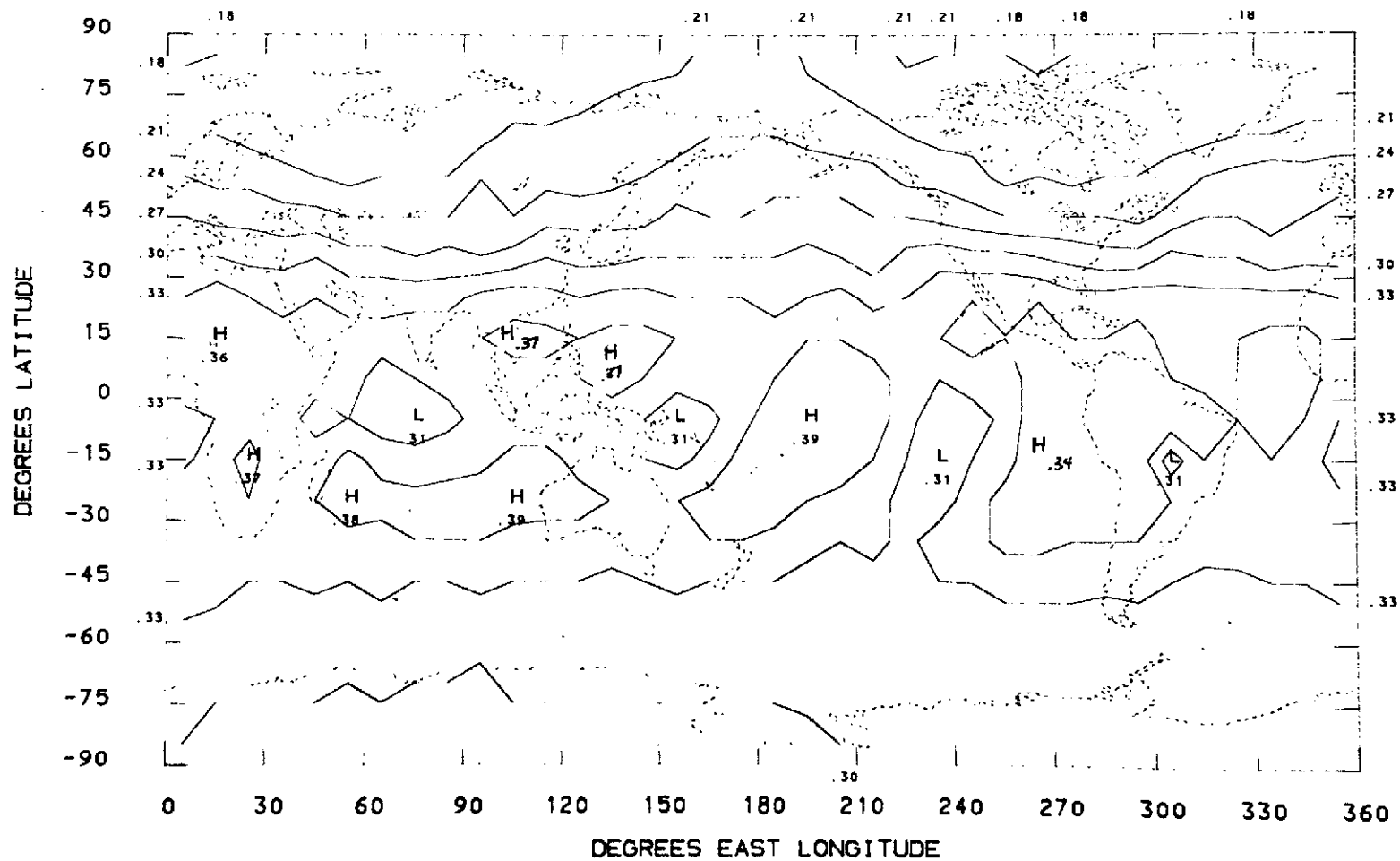
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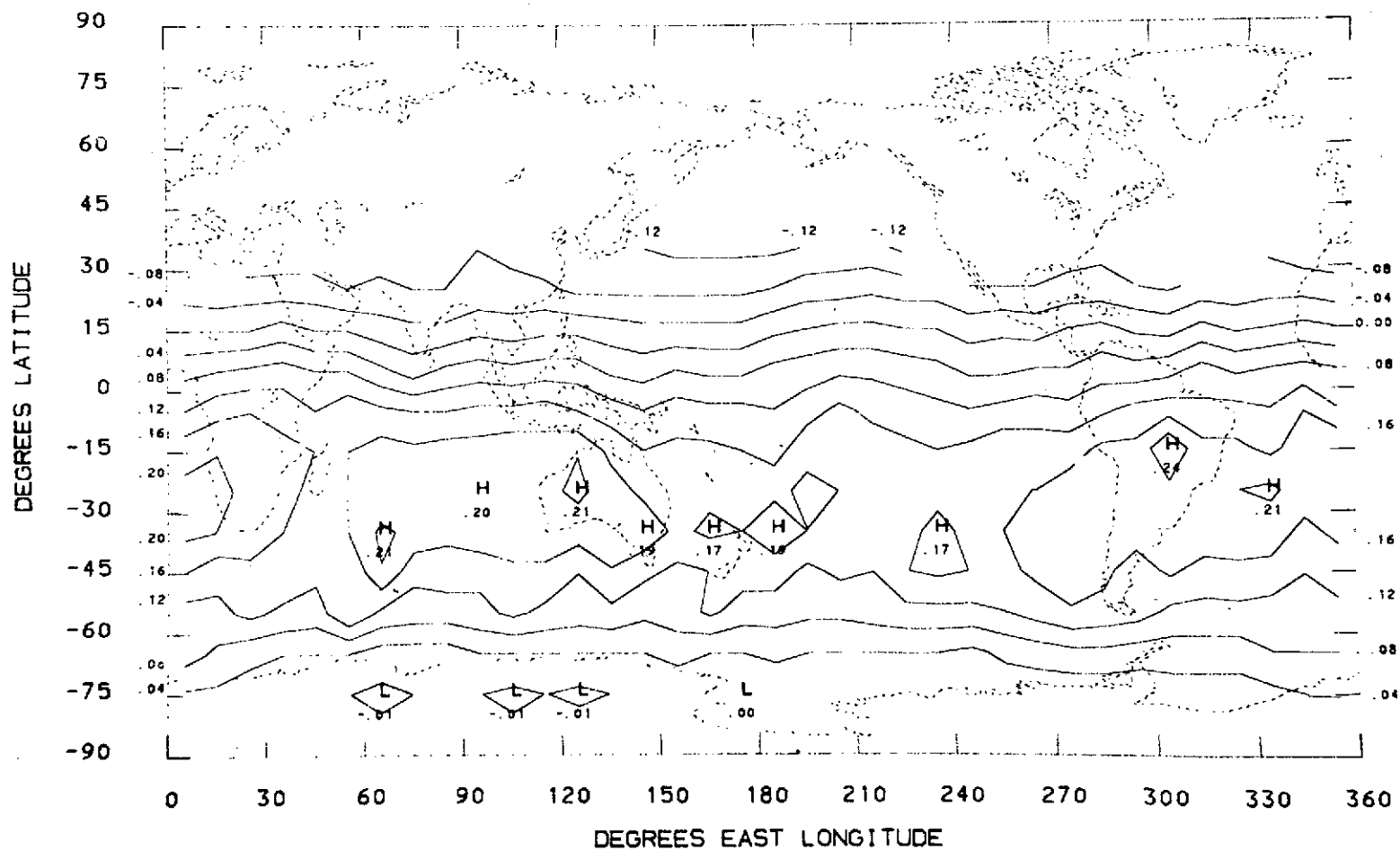


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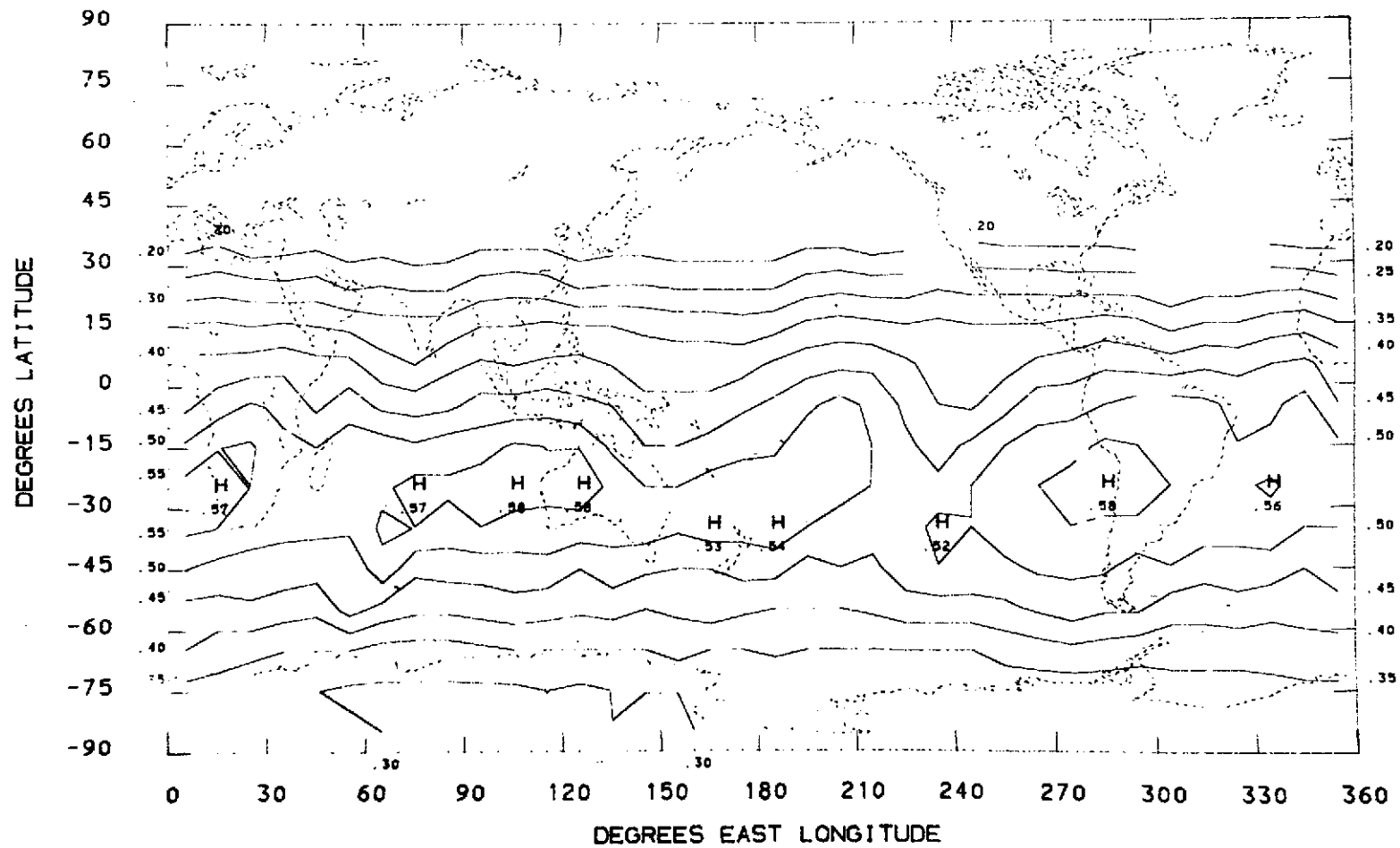


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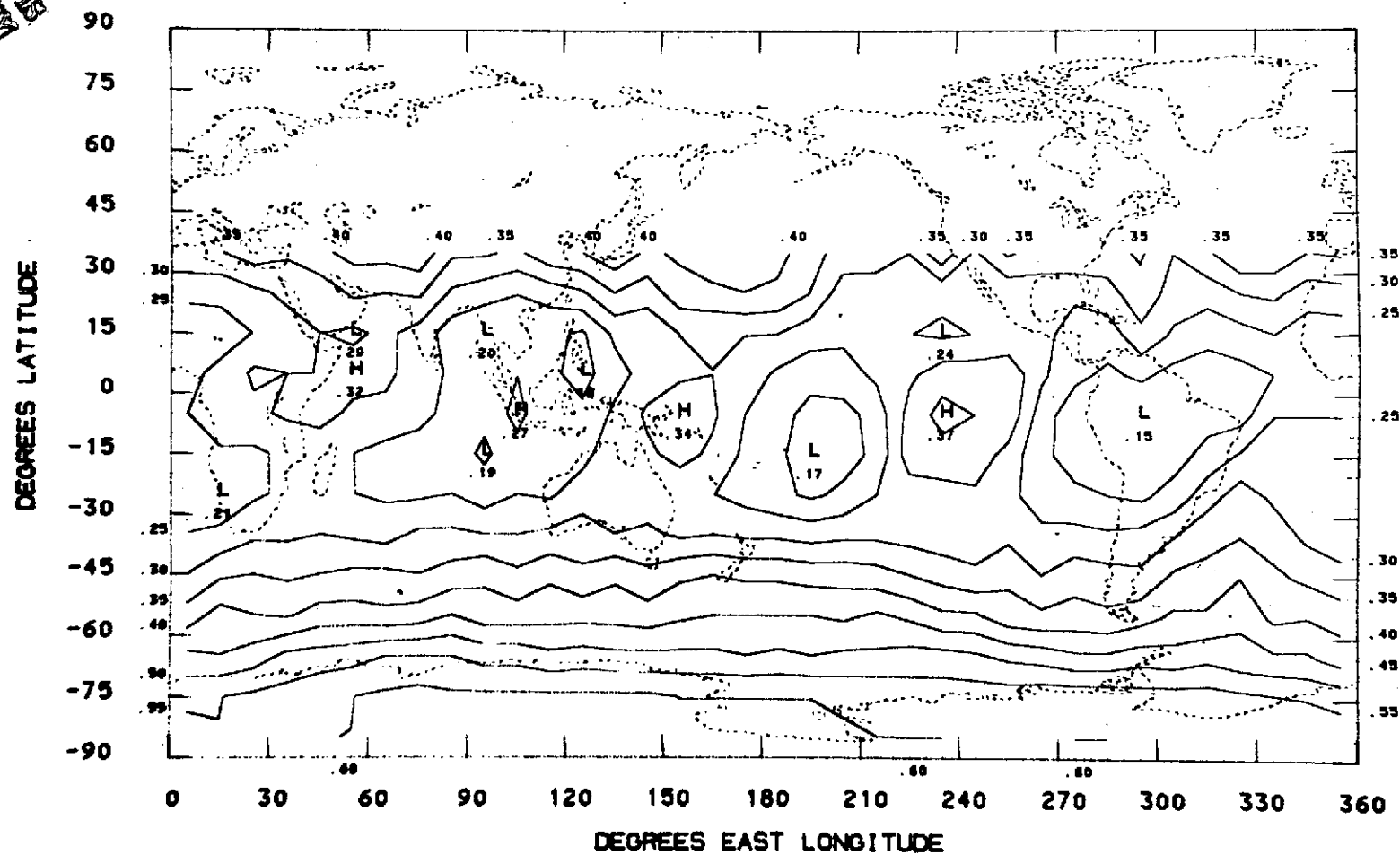


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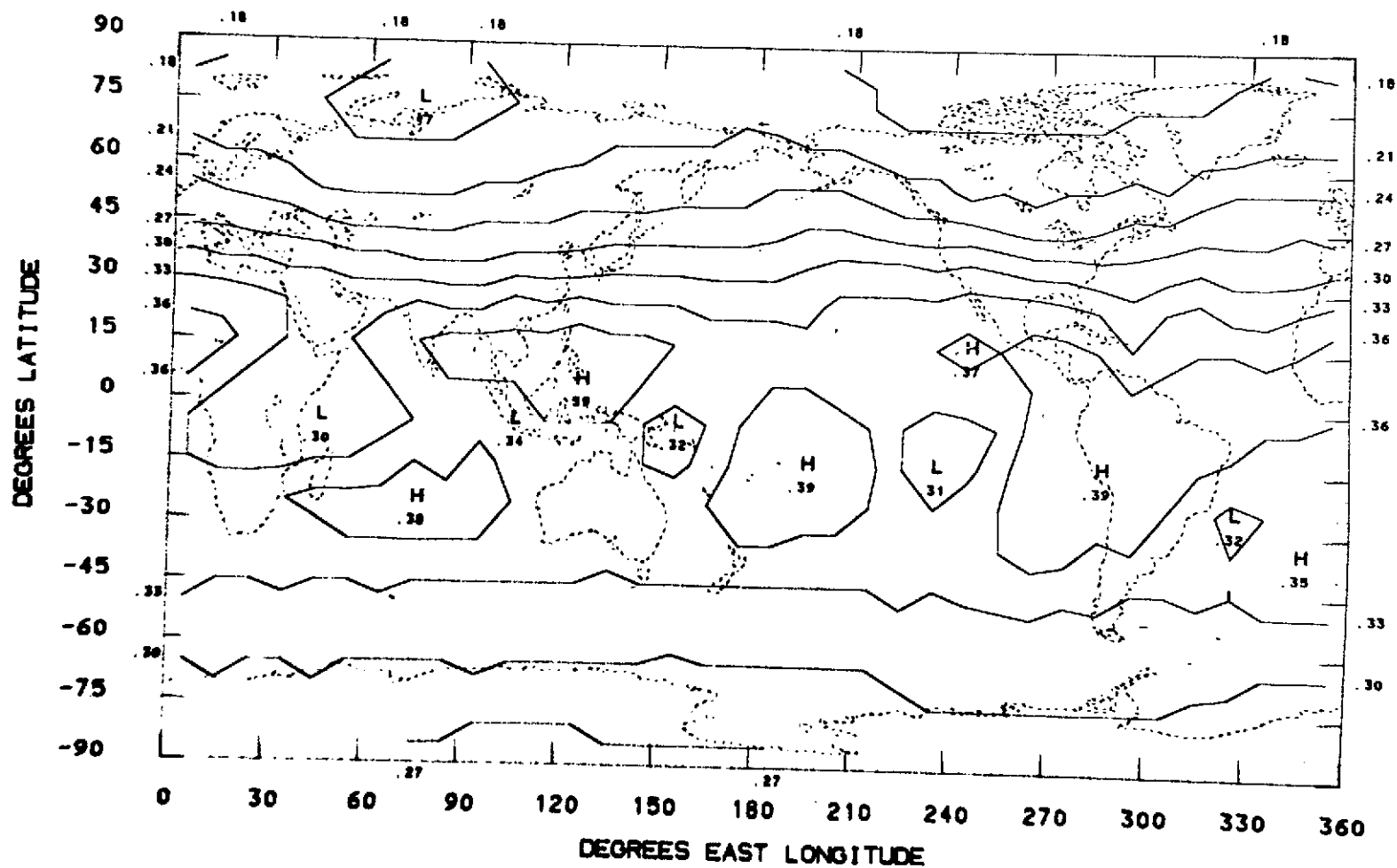


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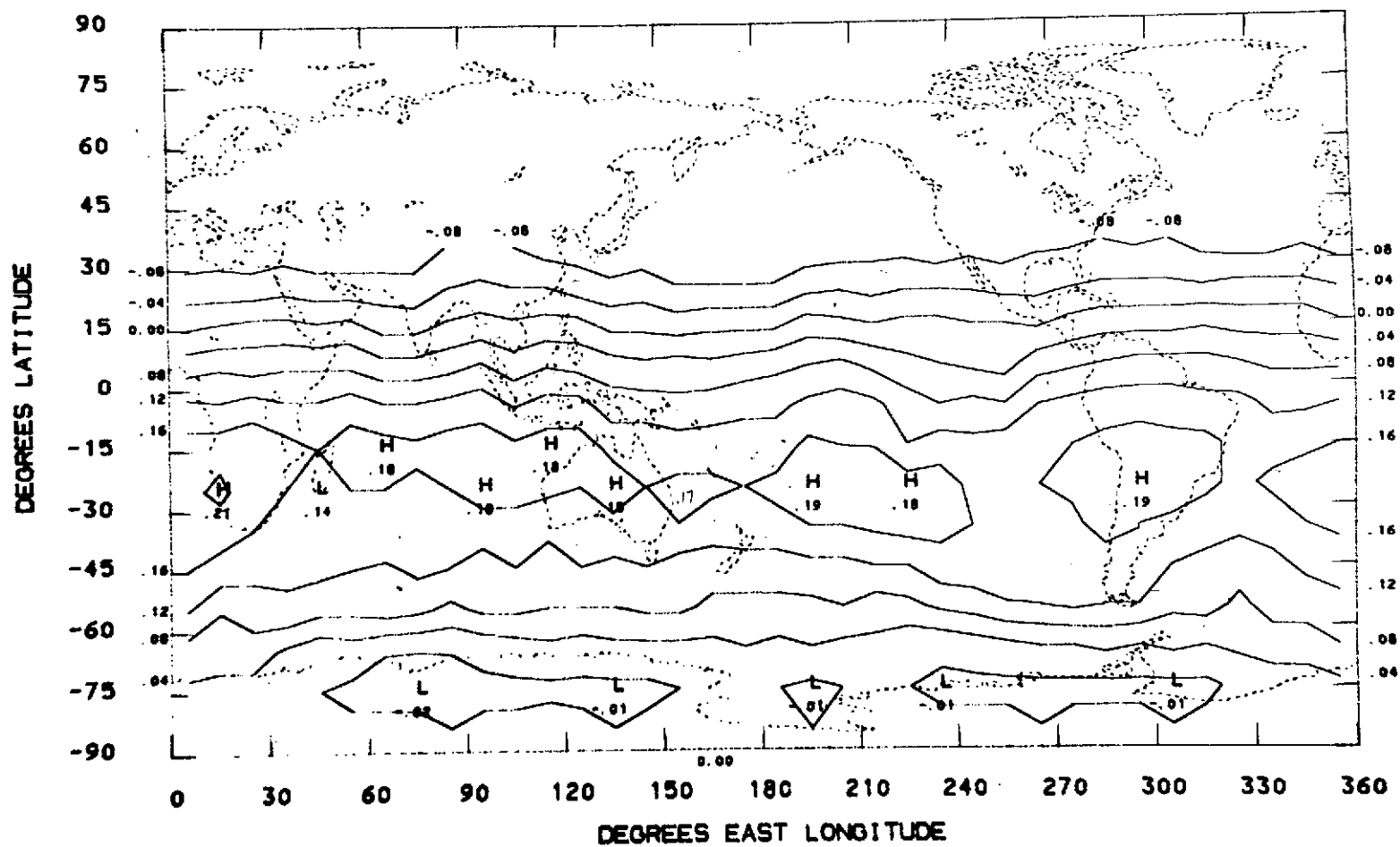


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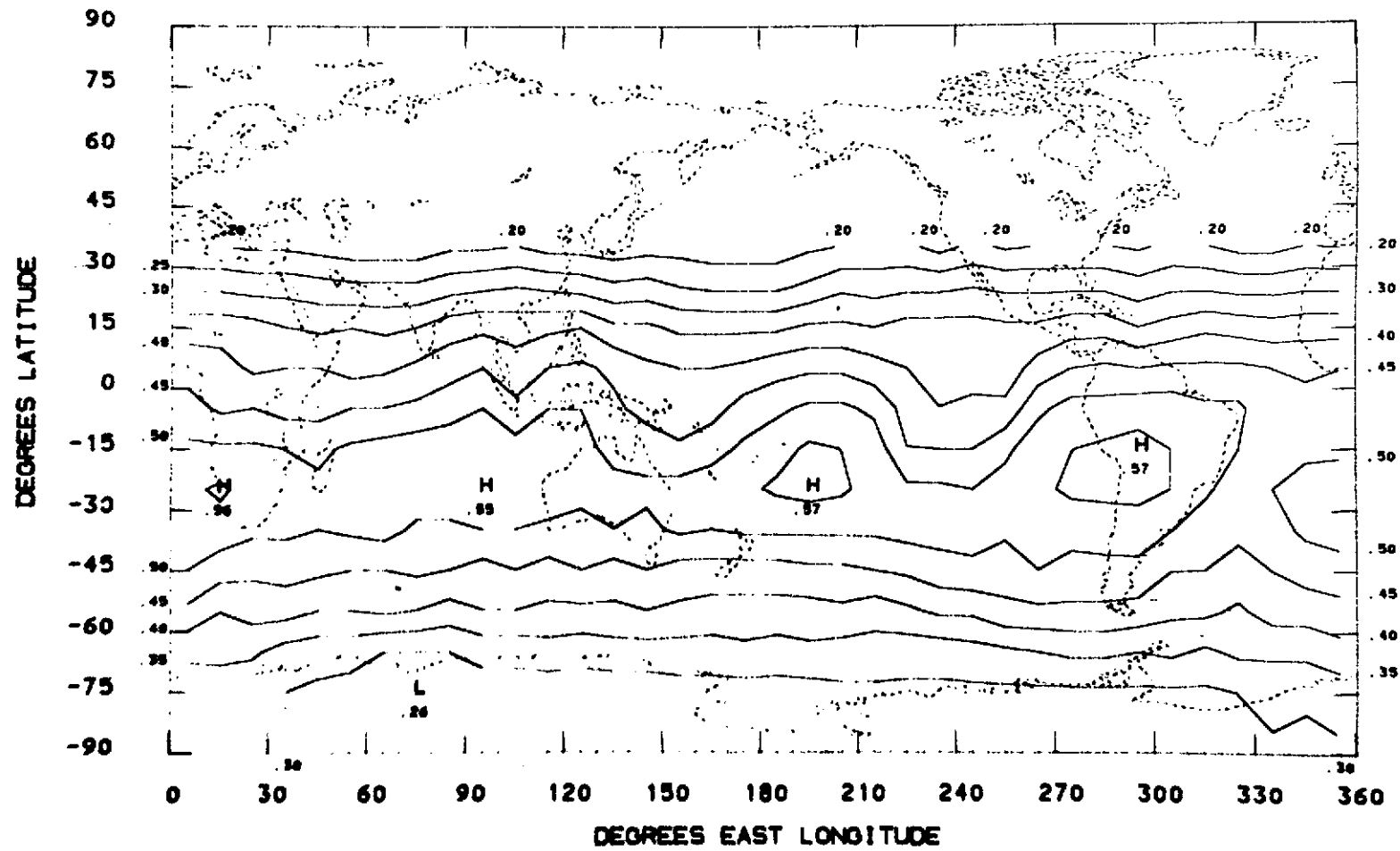


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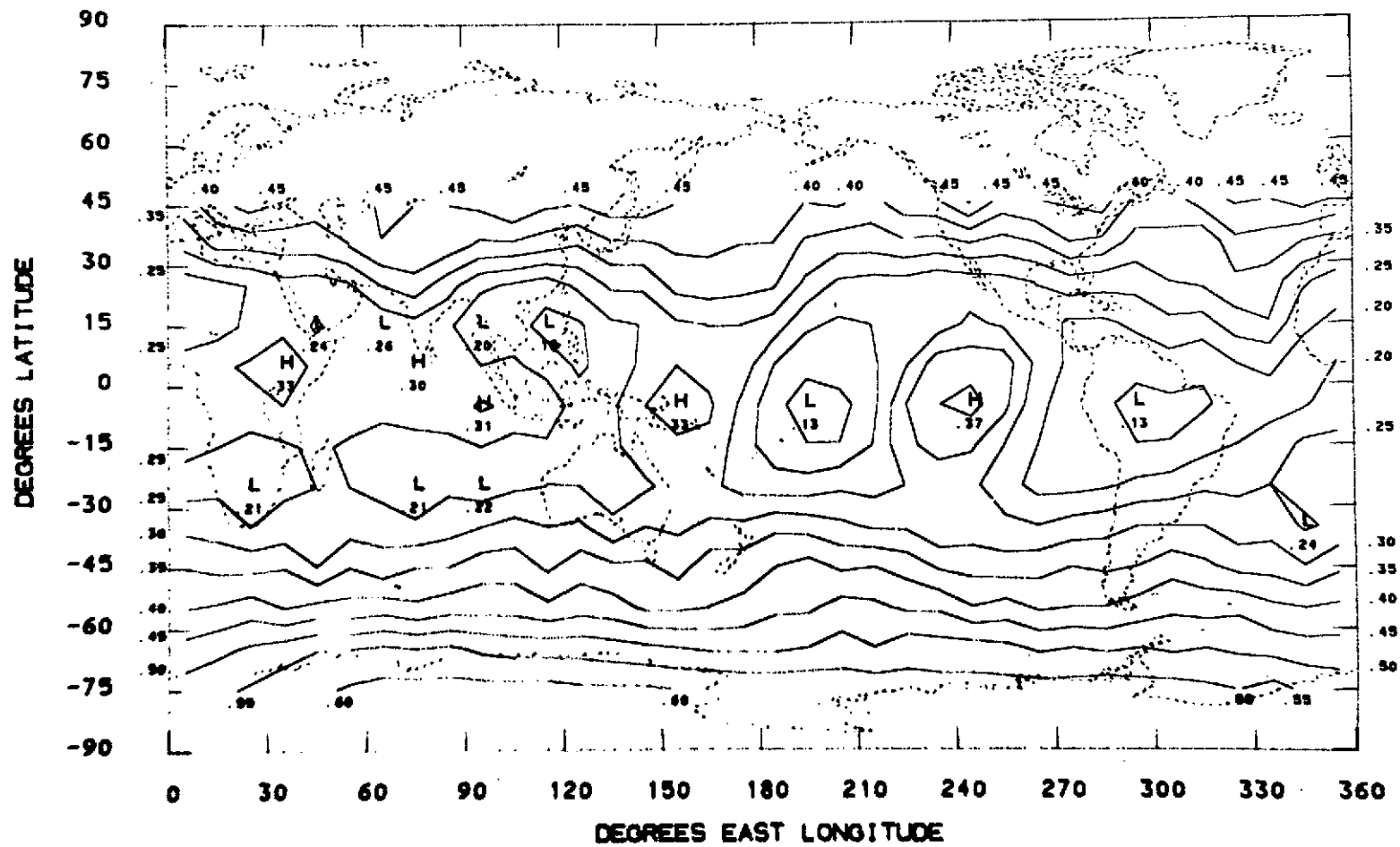
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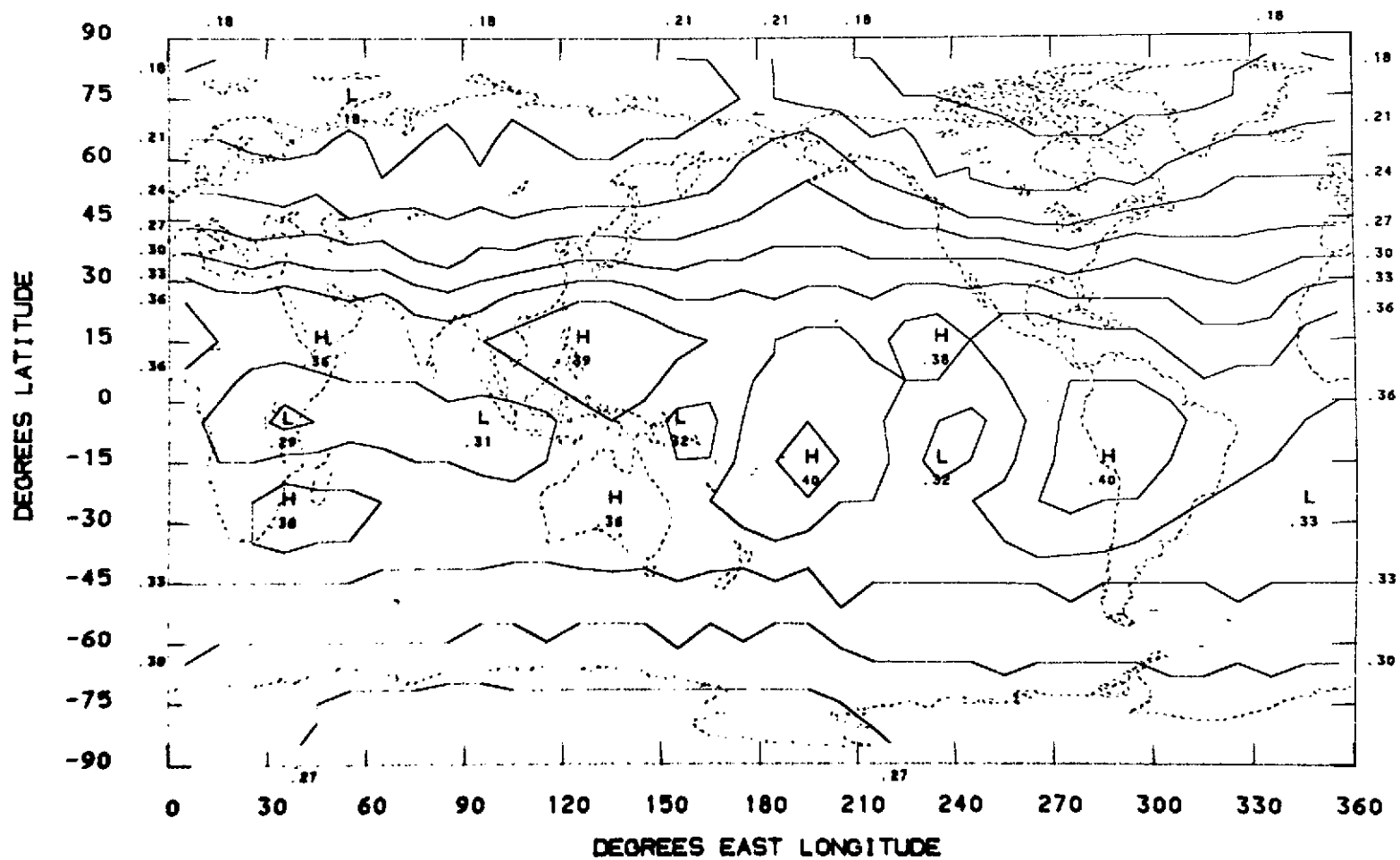
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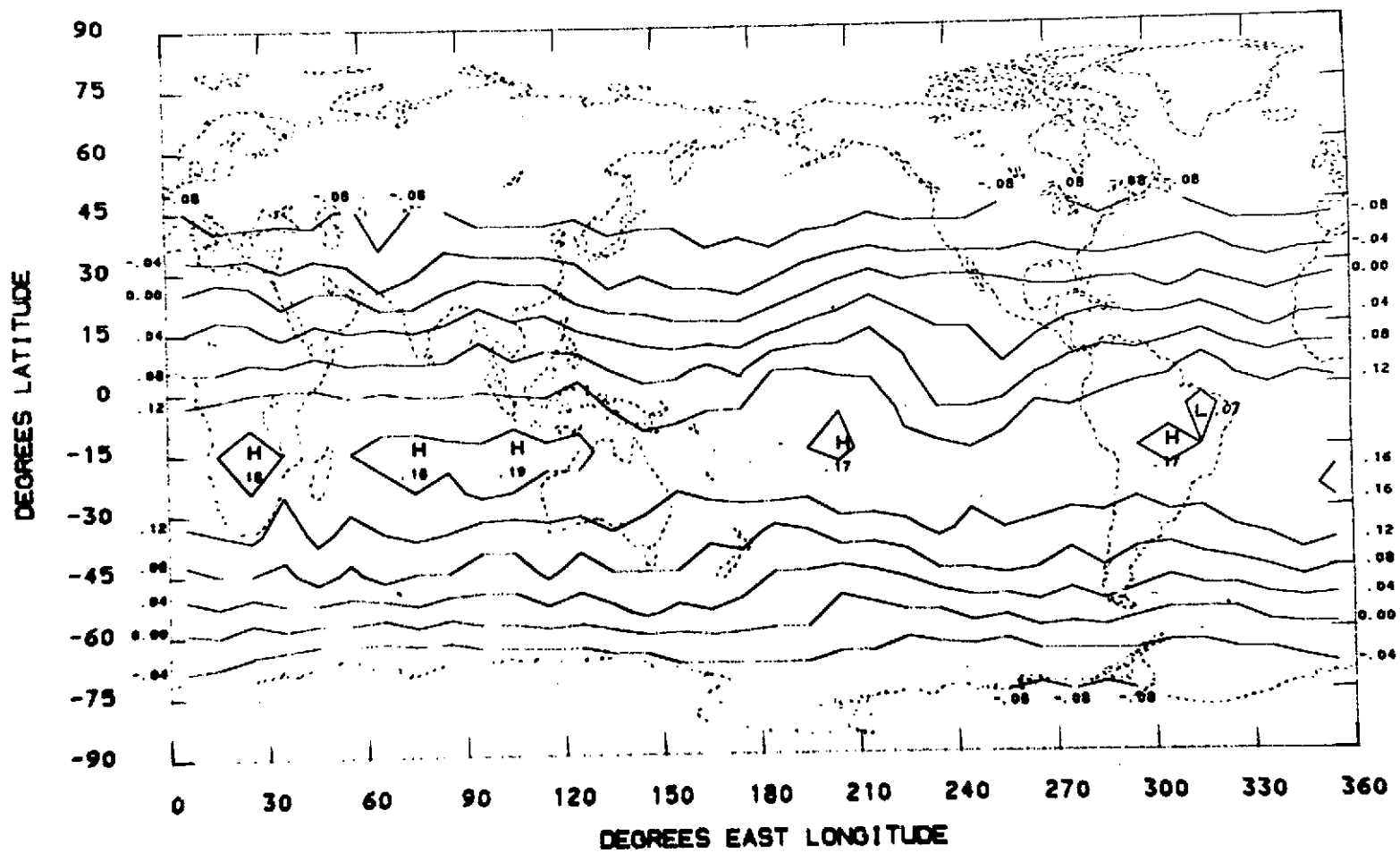
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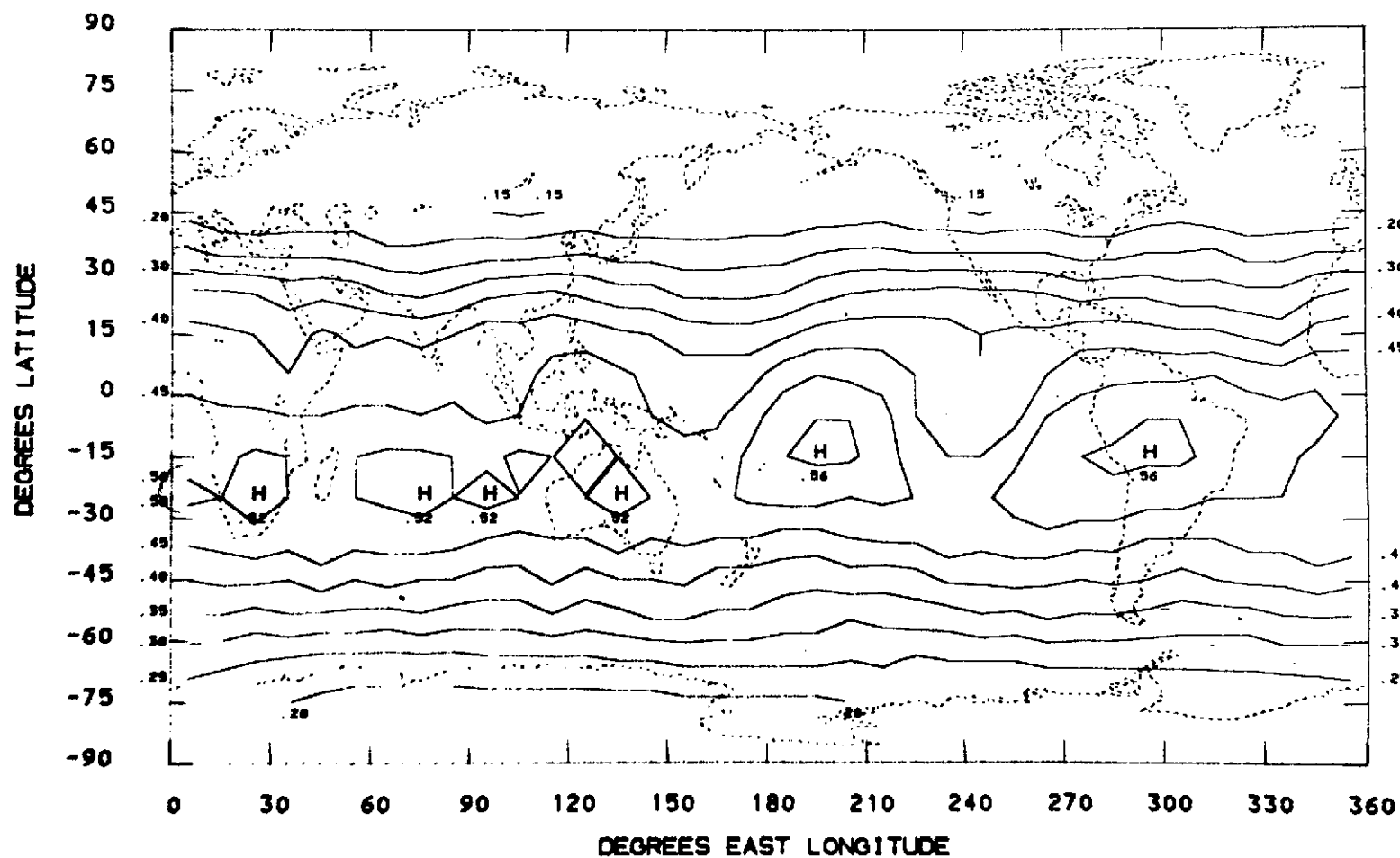
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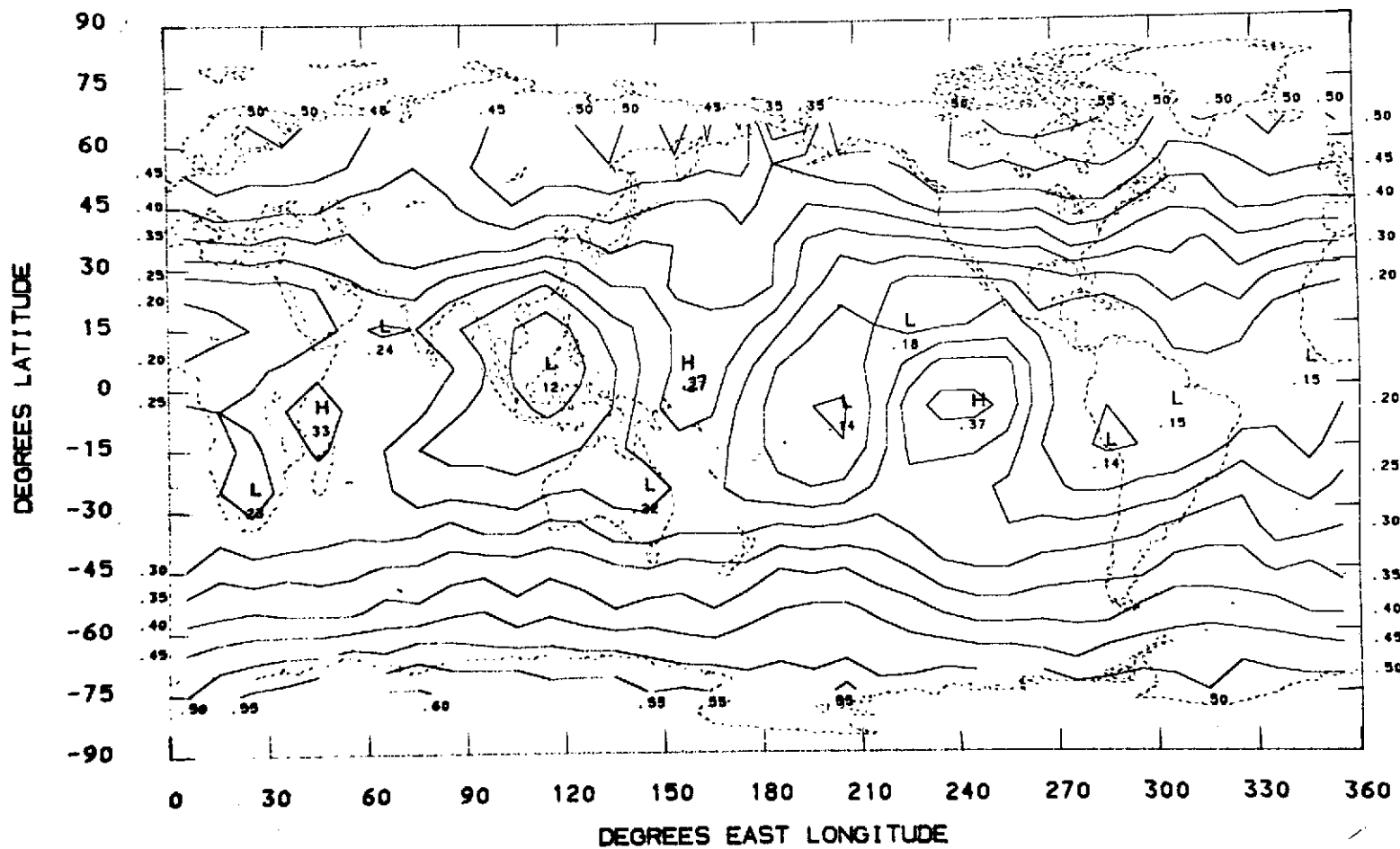


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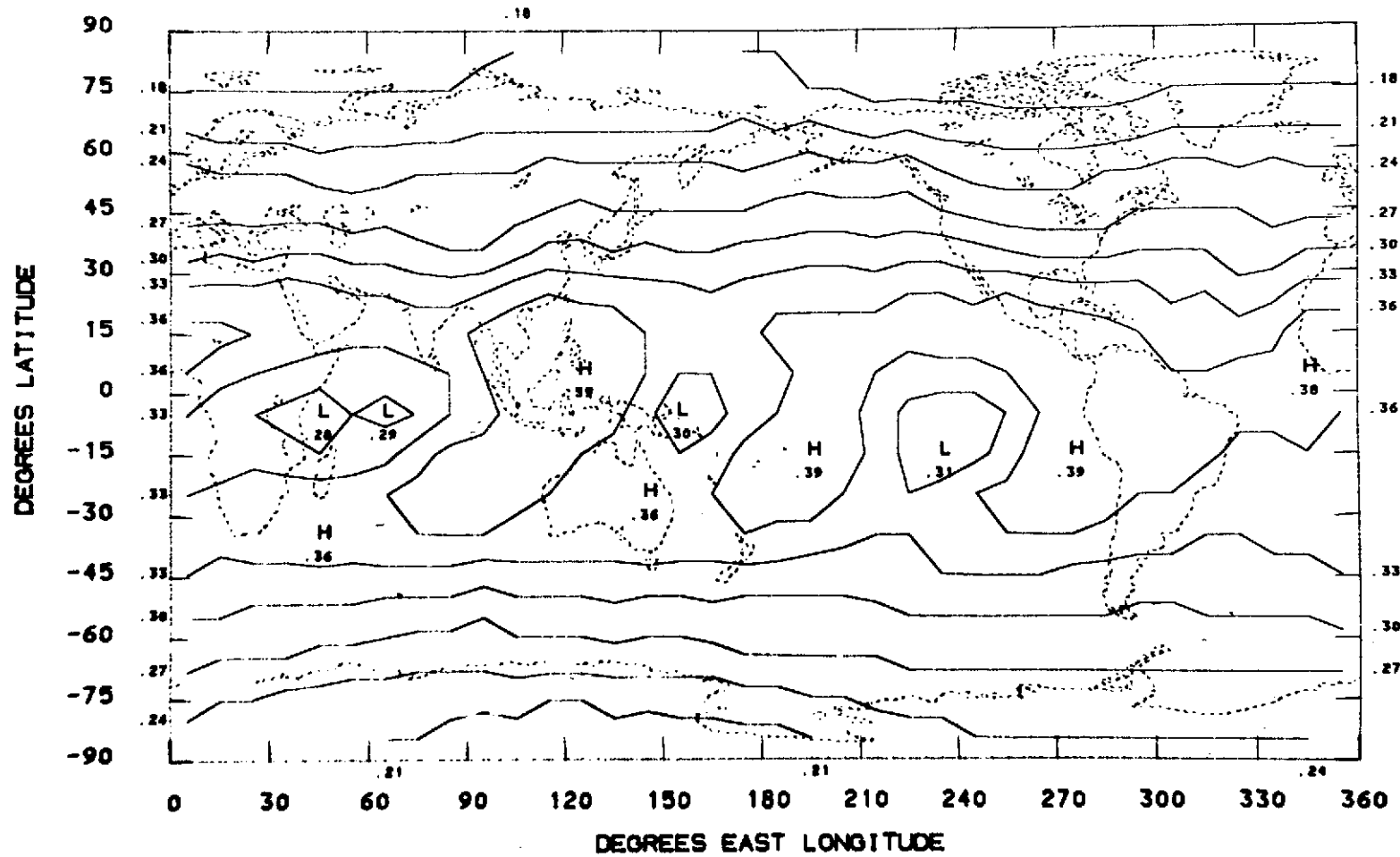


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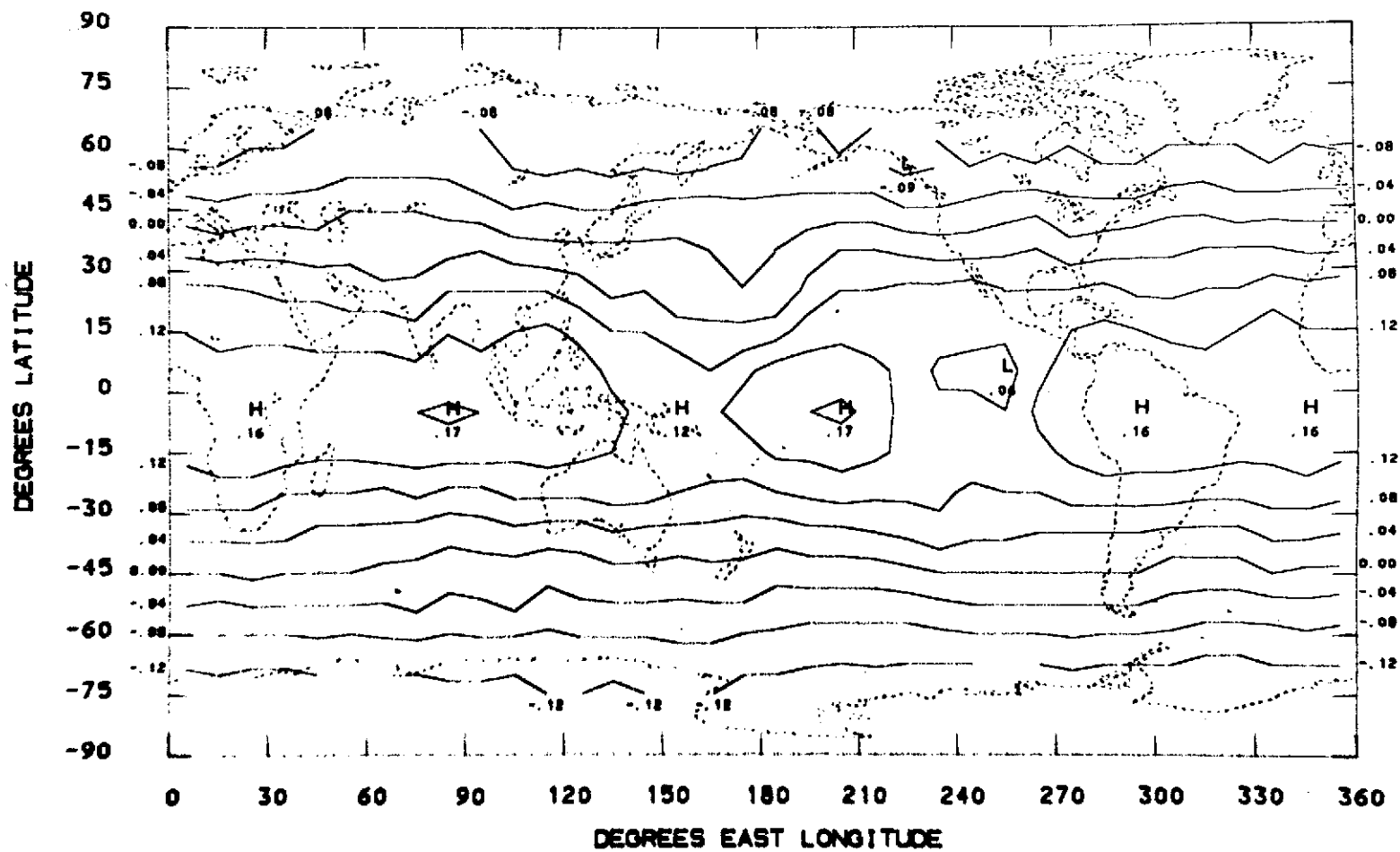
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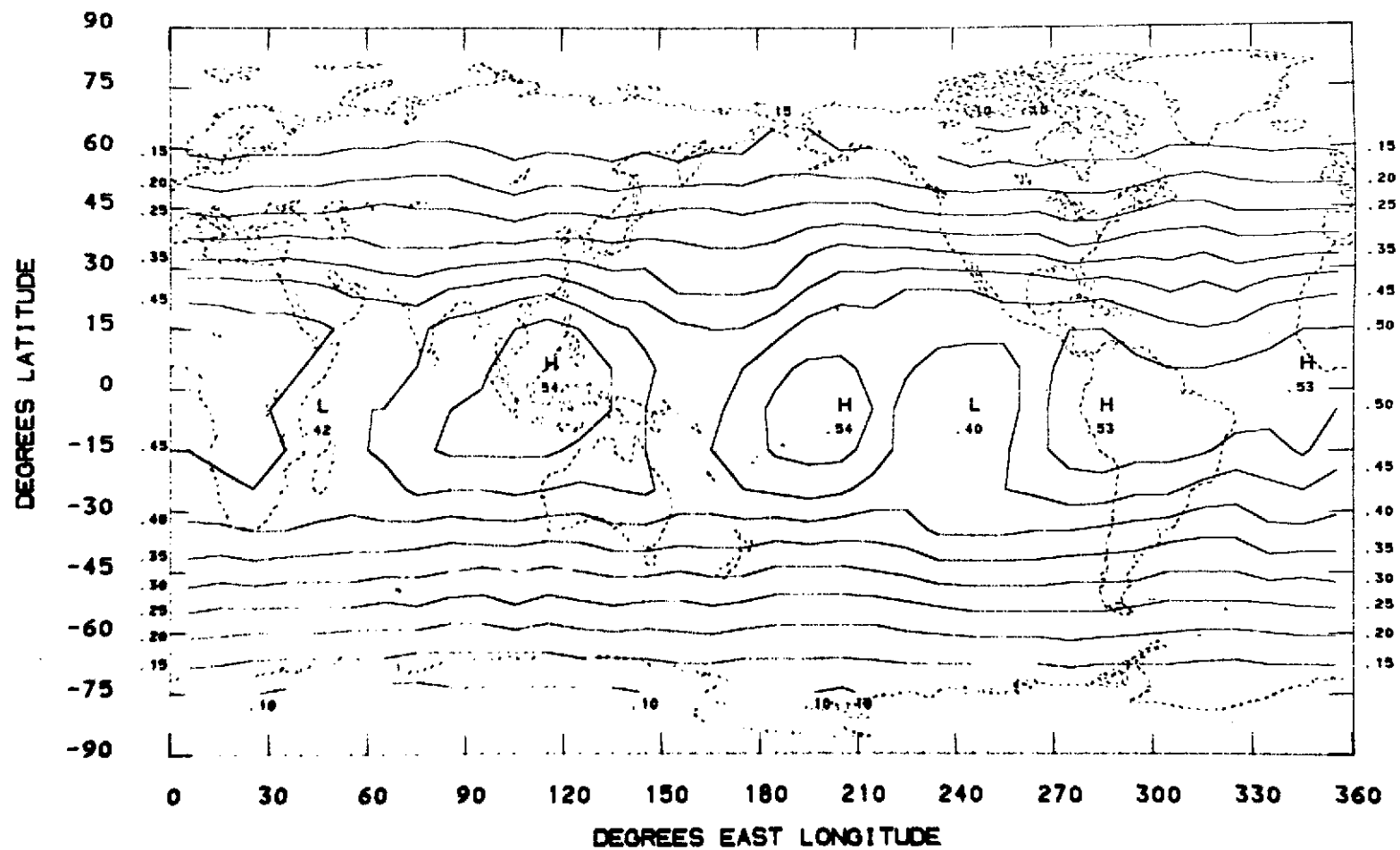
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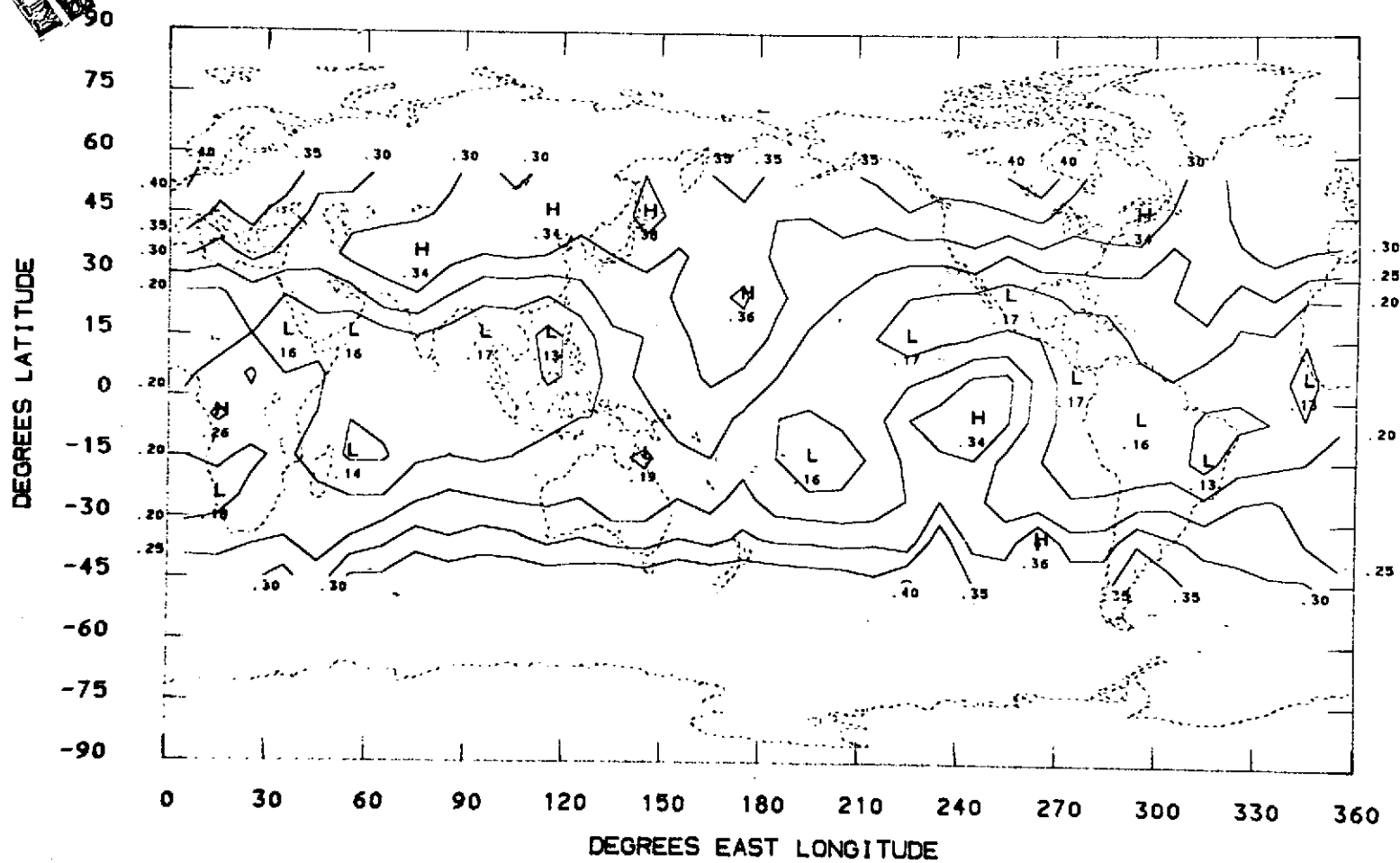


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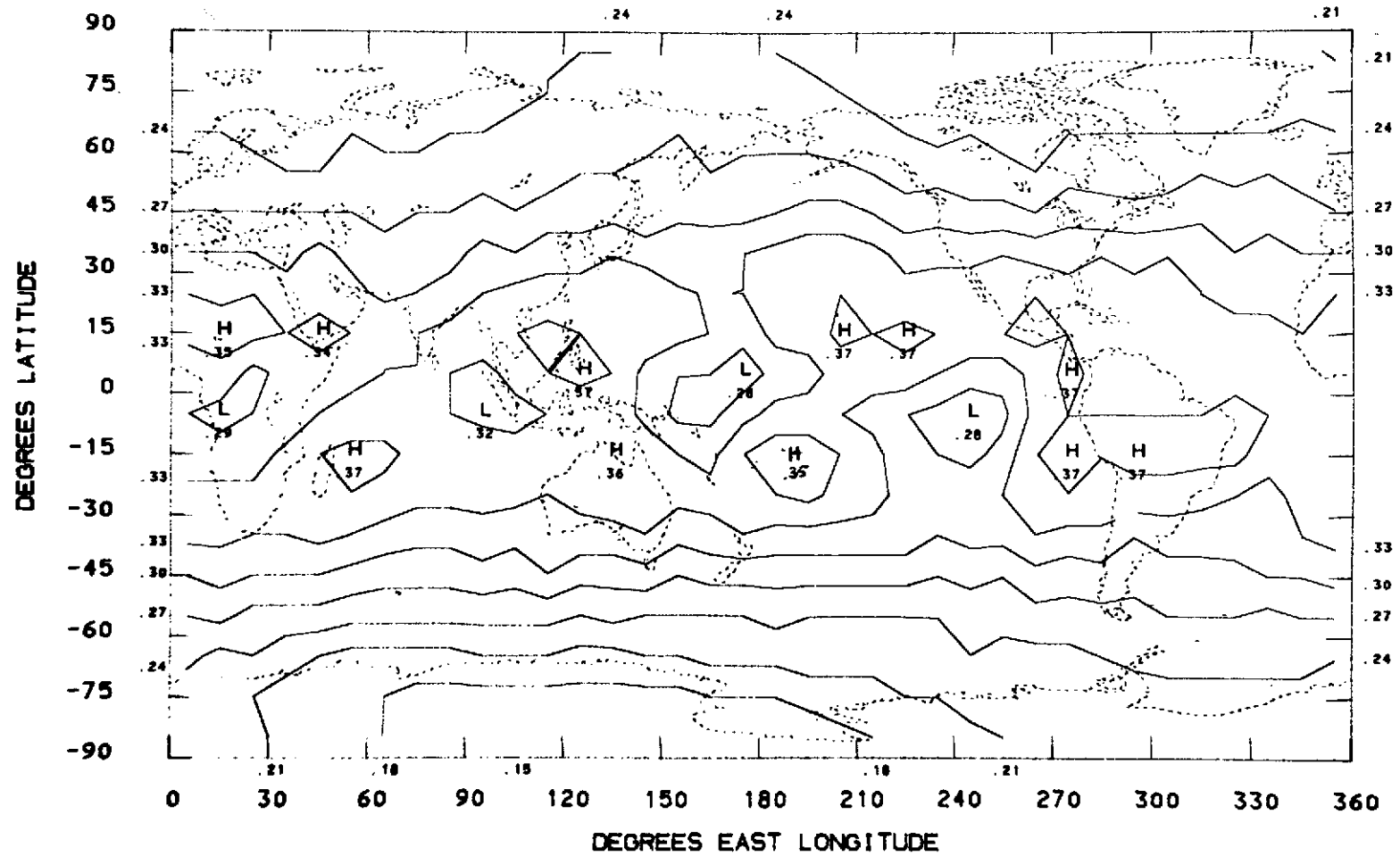


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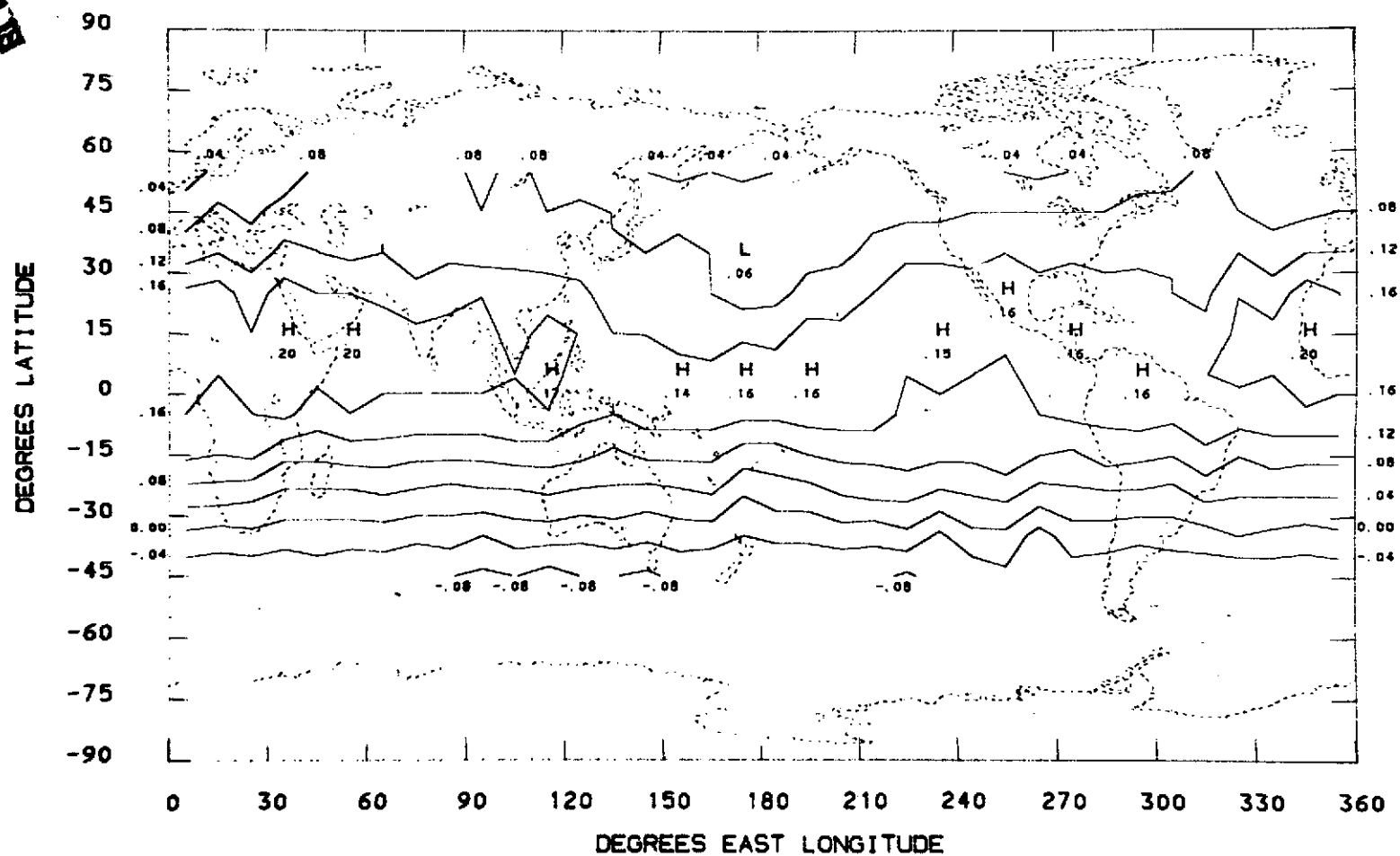


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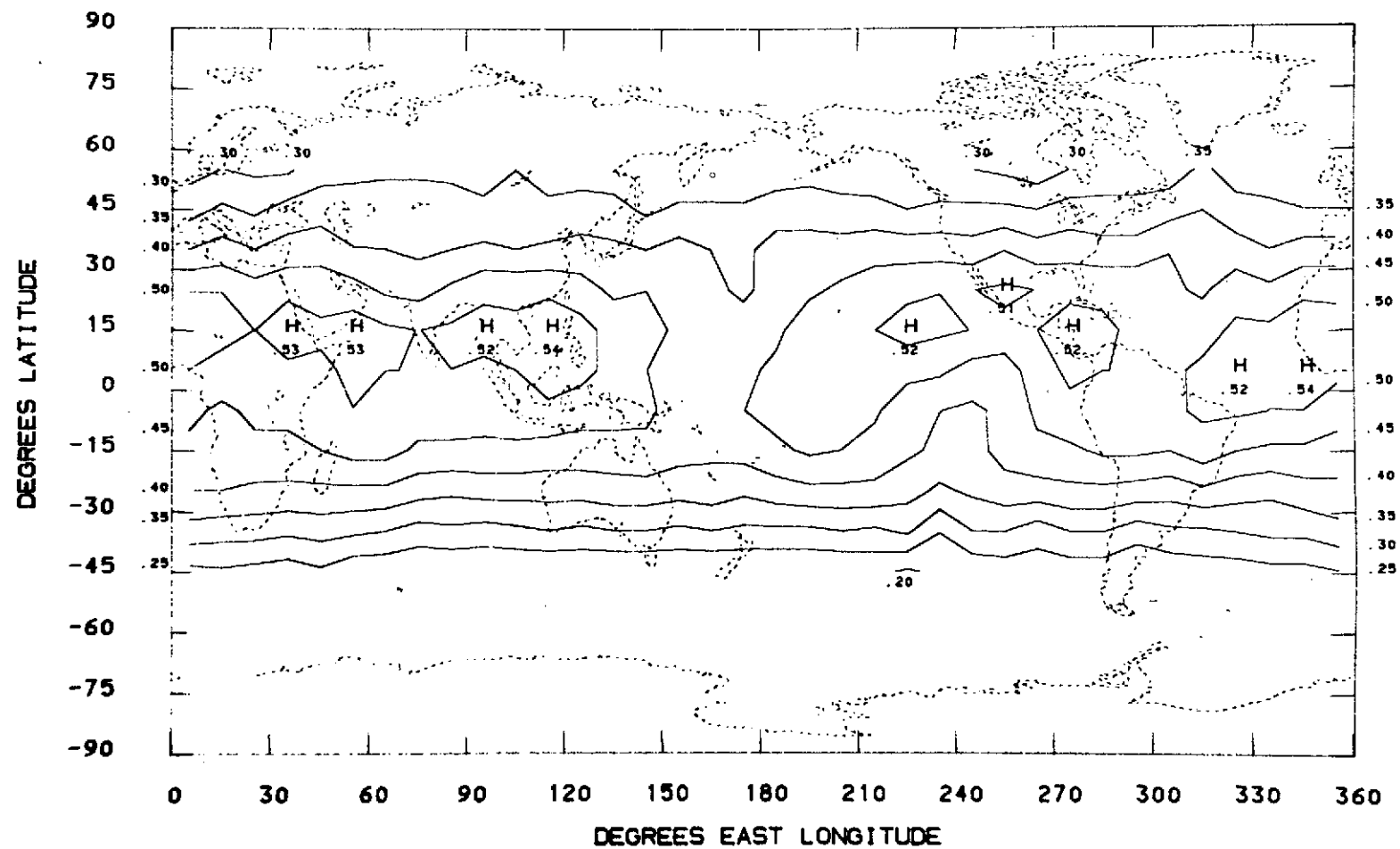


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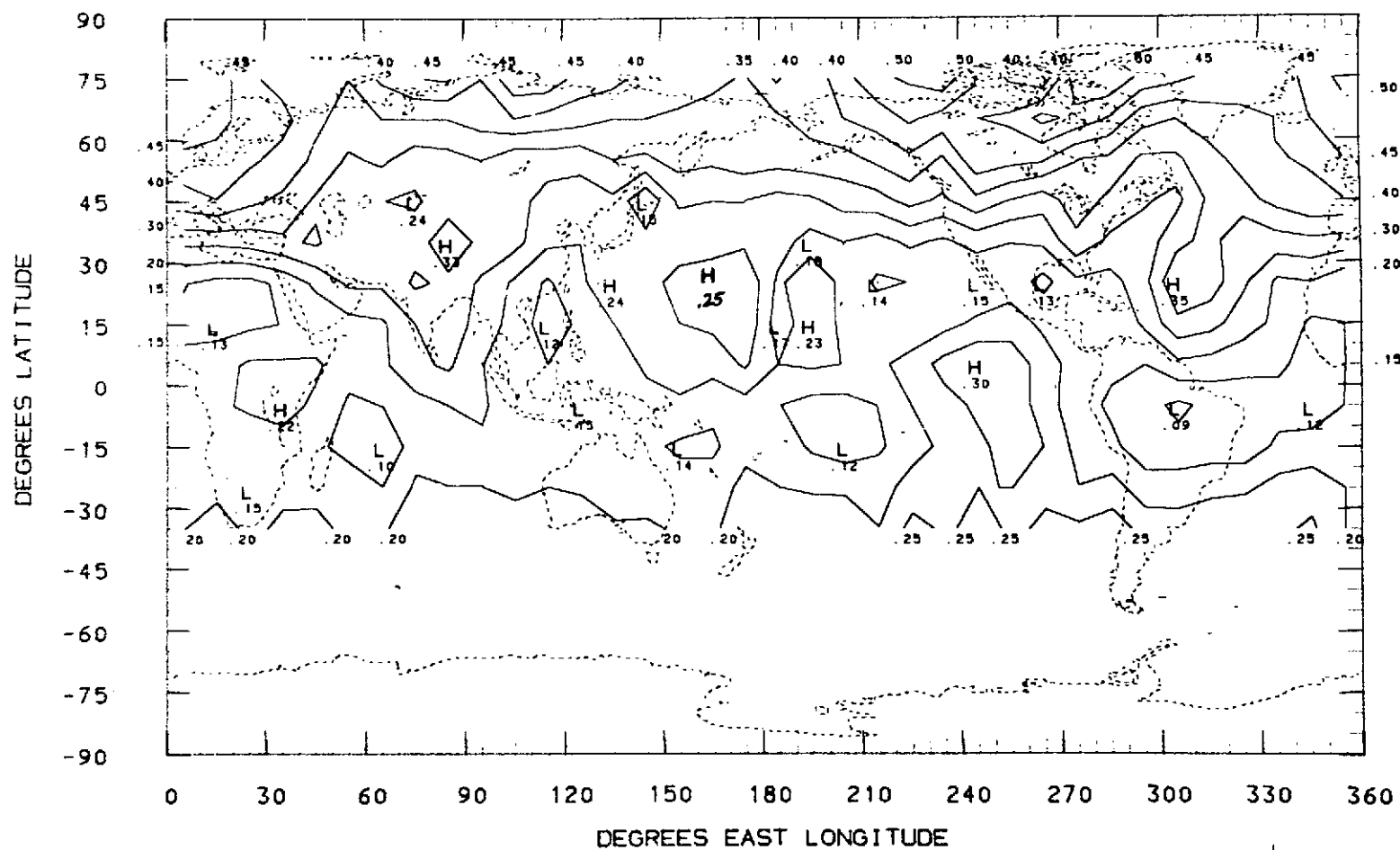
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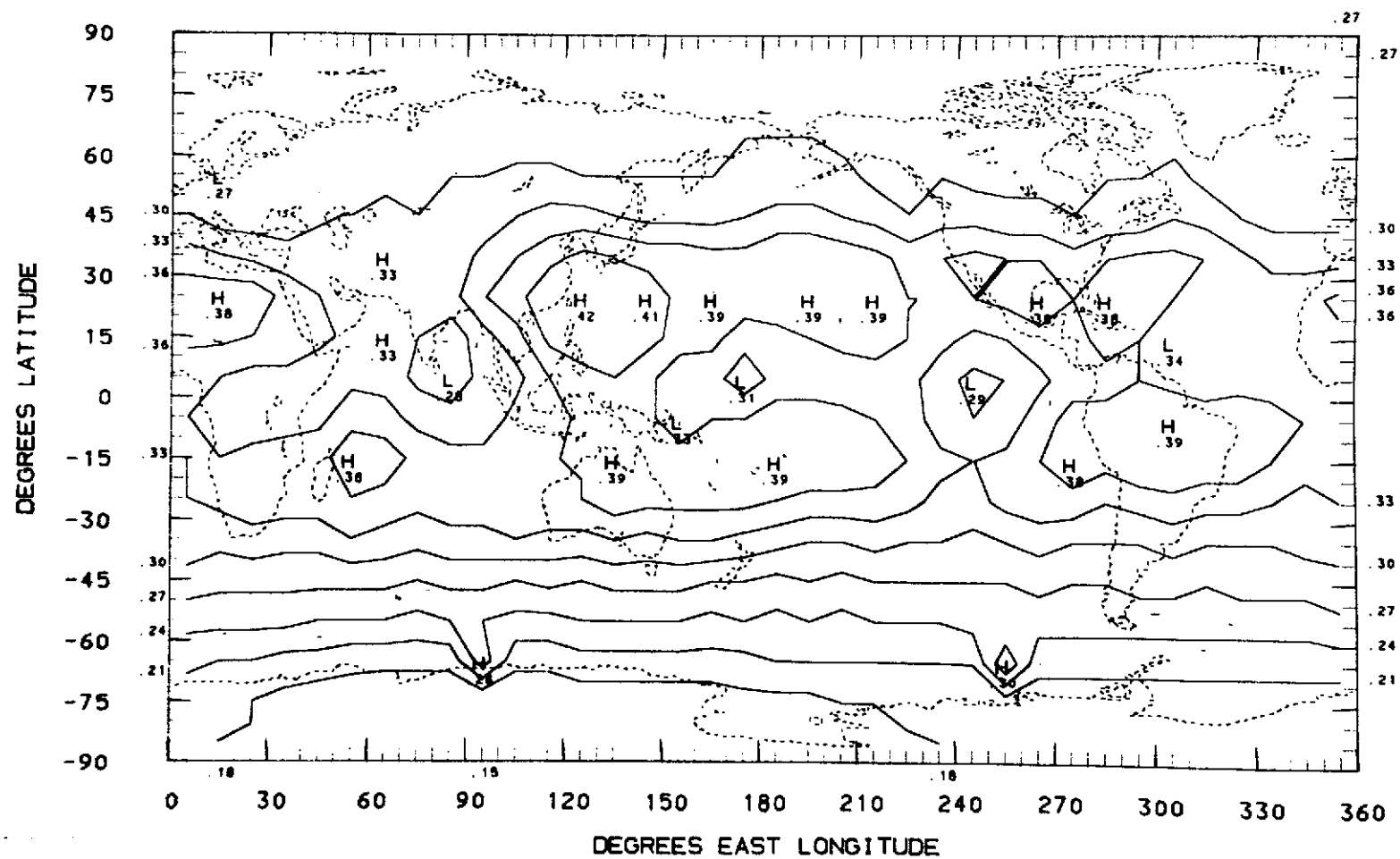
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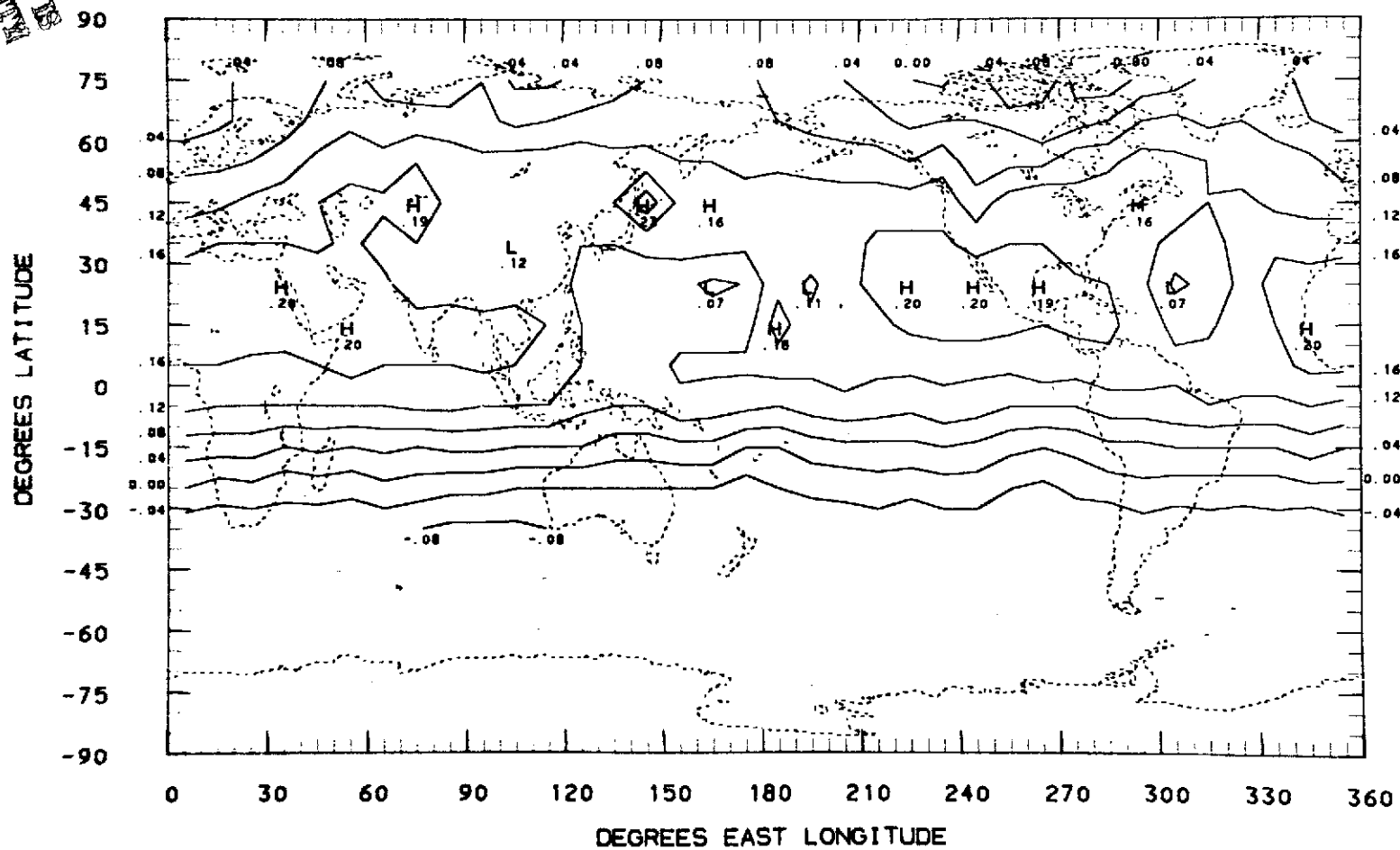


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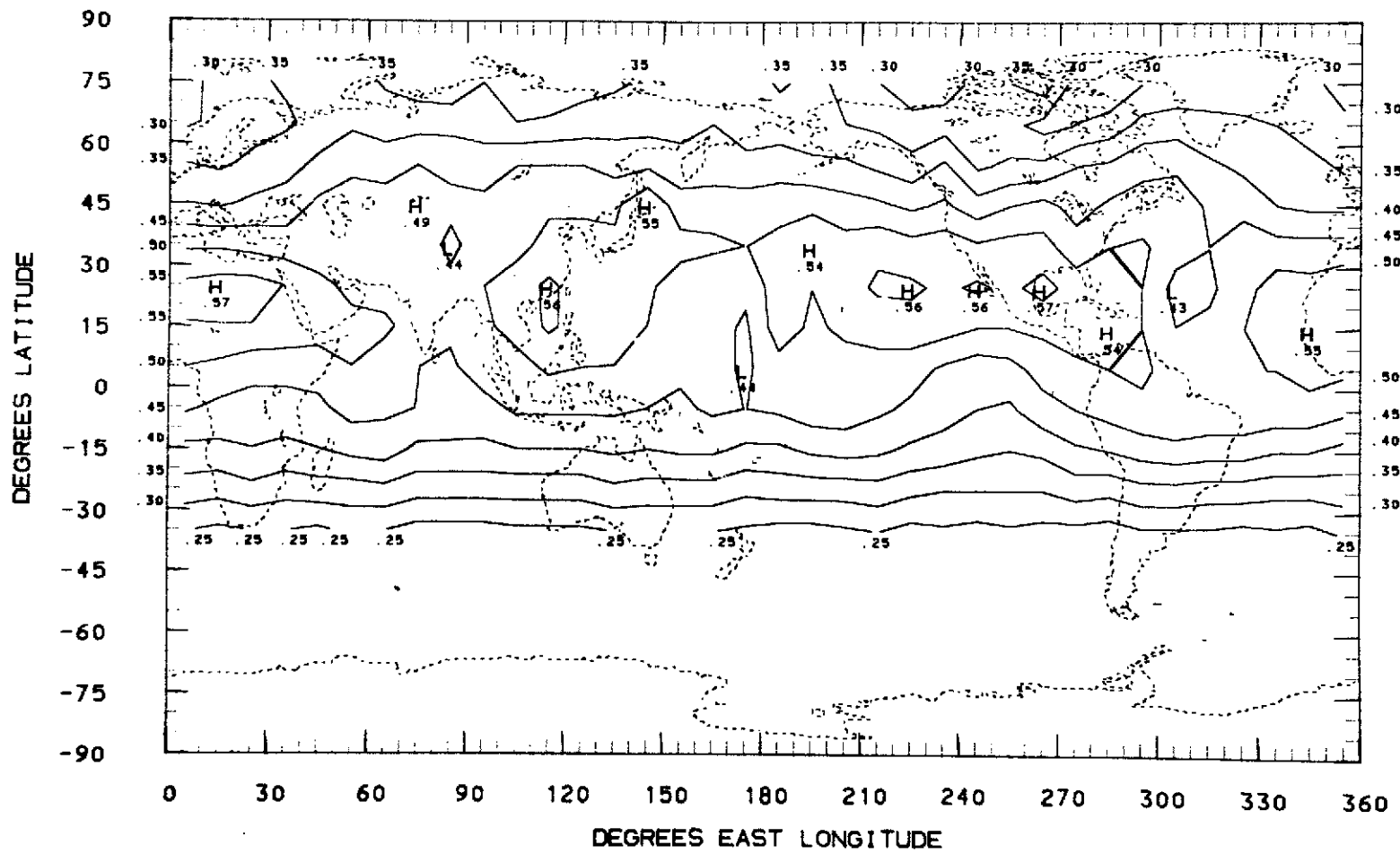
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NET RADIATION (LY/MIN)
MAY 1965



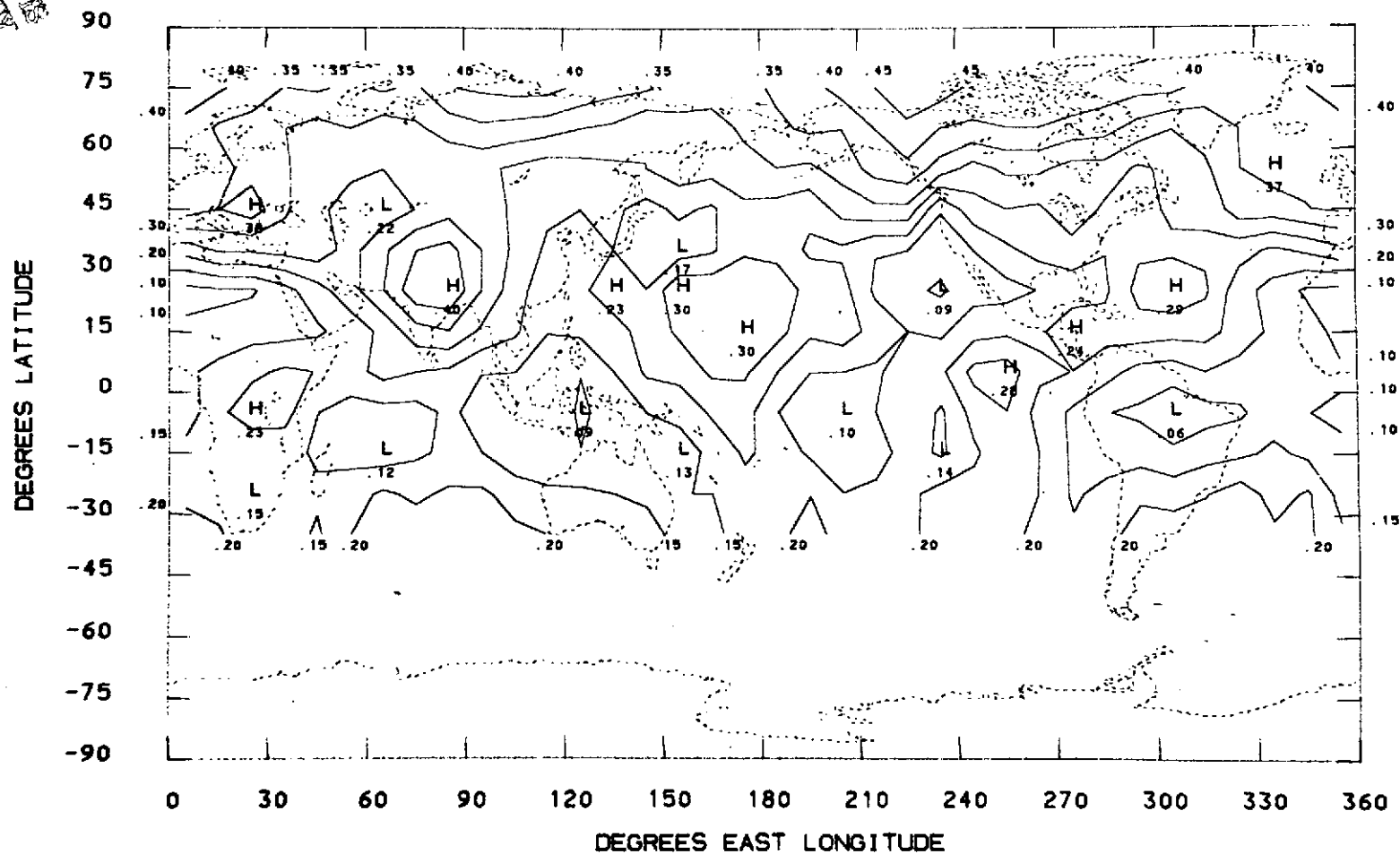
ABSORBED RADIATION (LY/MIN)

MAY 1965

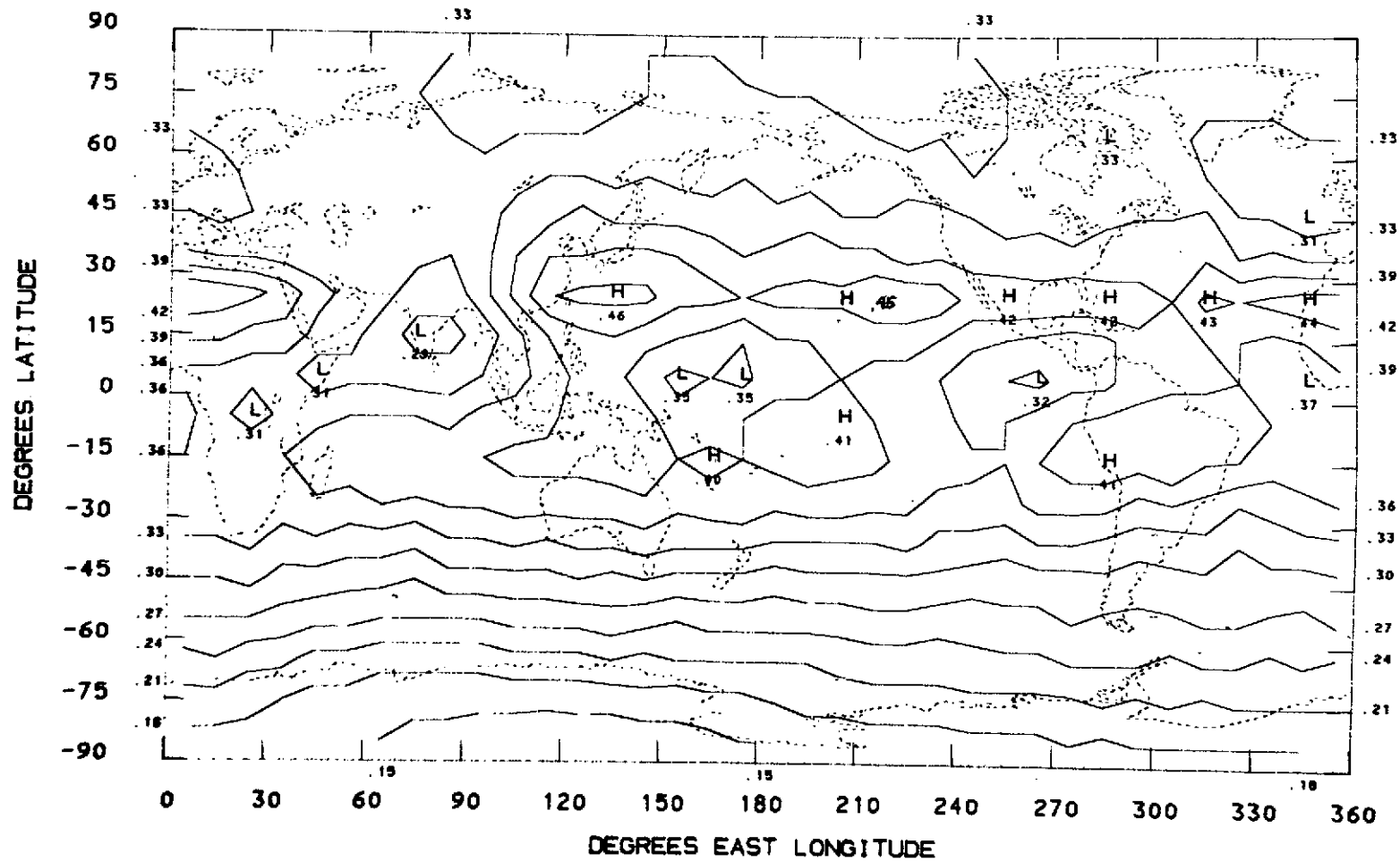


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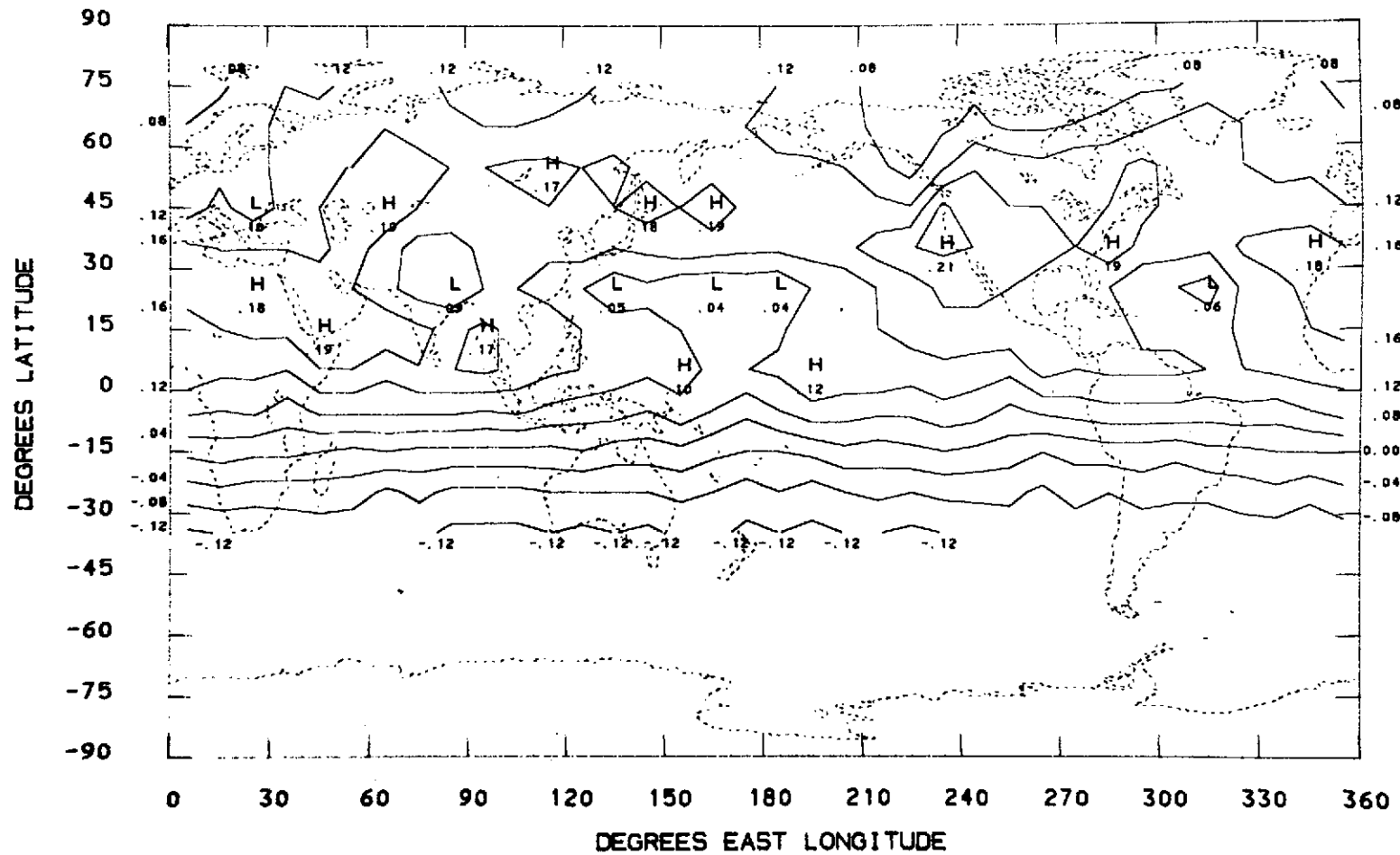
PLANETARY ALBEDO
JUNE 1965



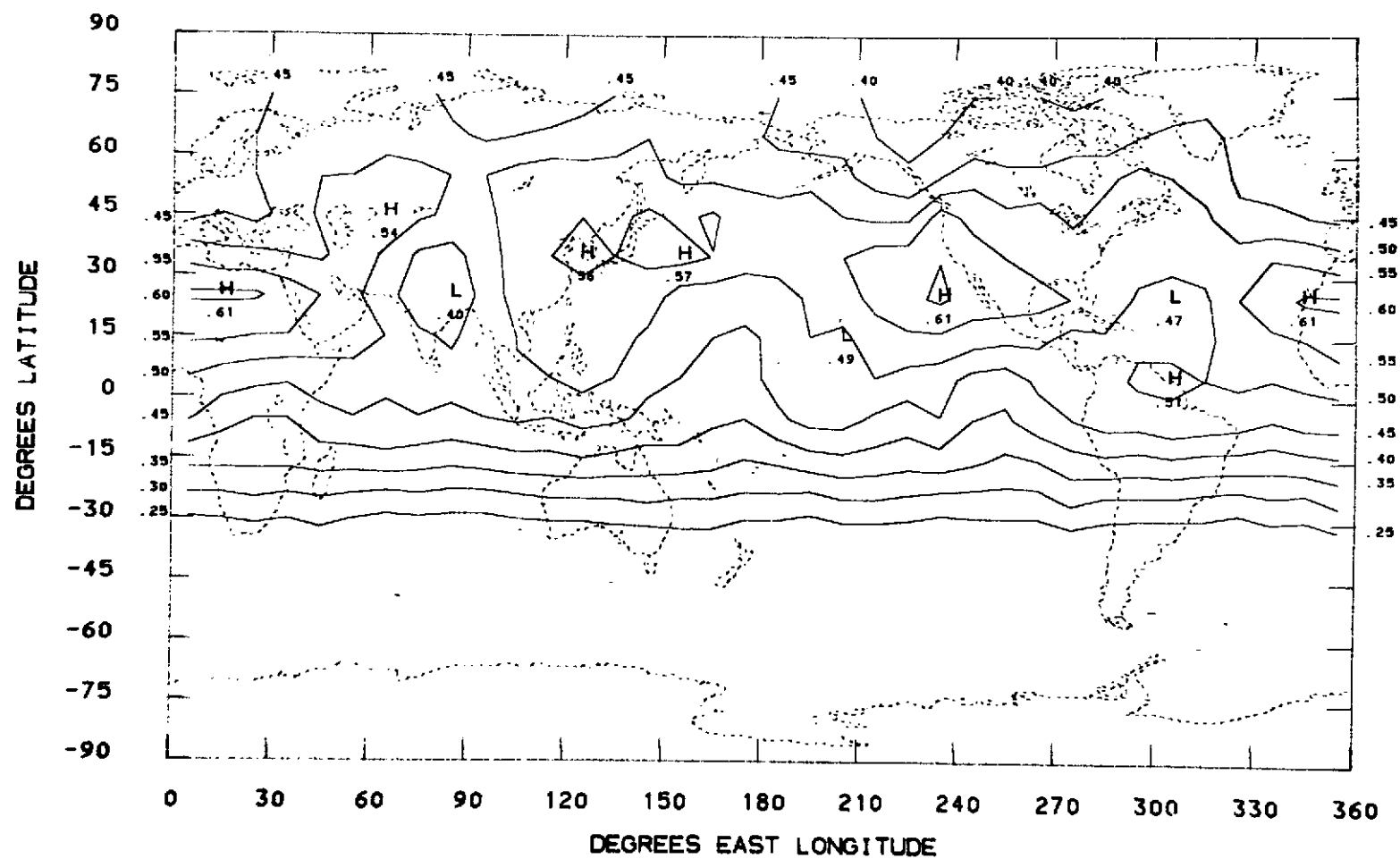
LONGWAVE RADIATION (LY/MIN)
JUNE 1965



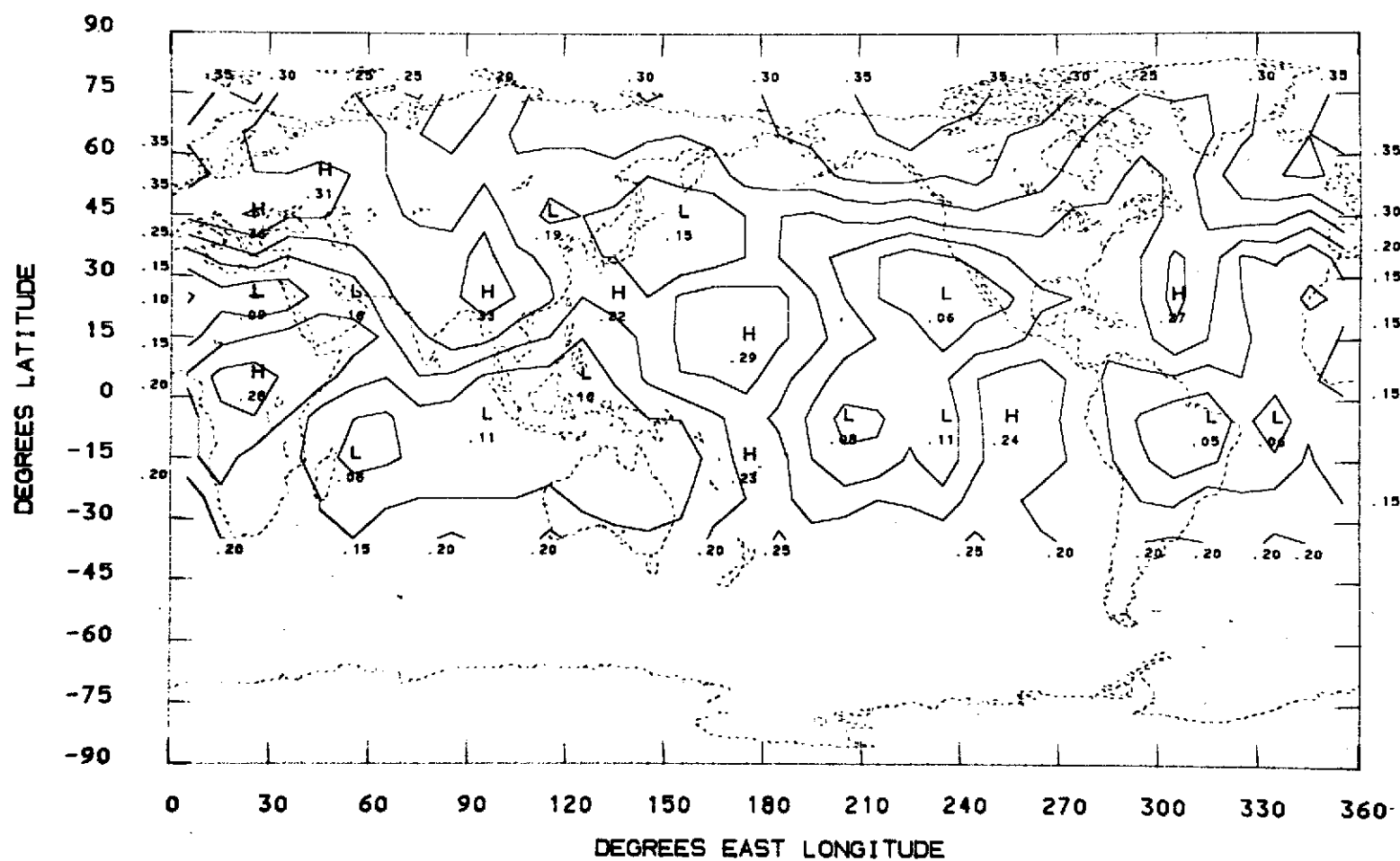
NET RADIATION (LY/MIN)
JUNE 1965



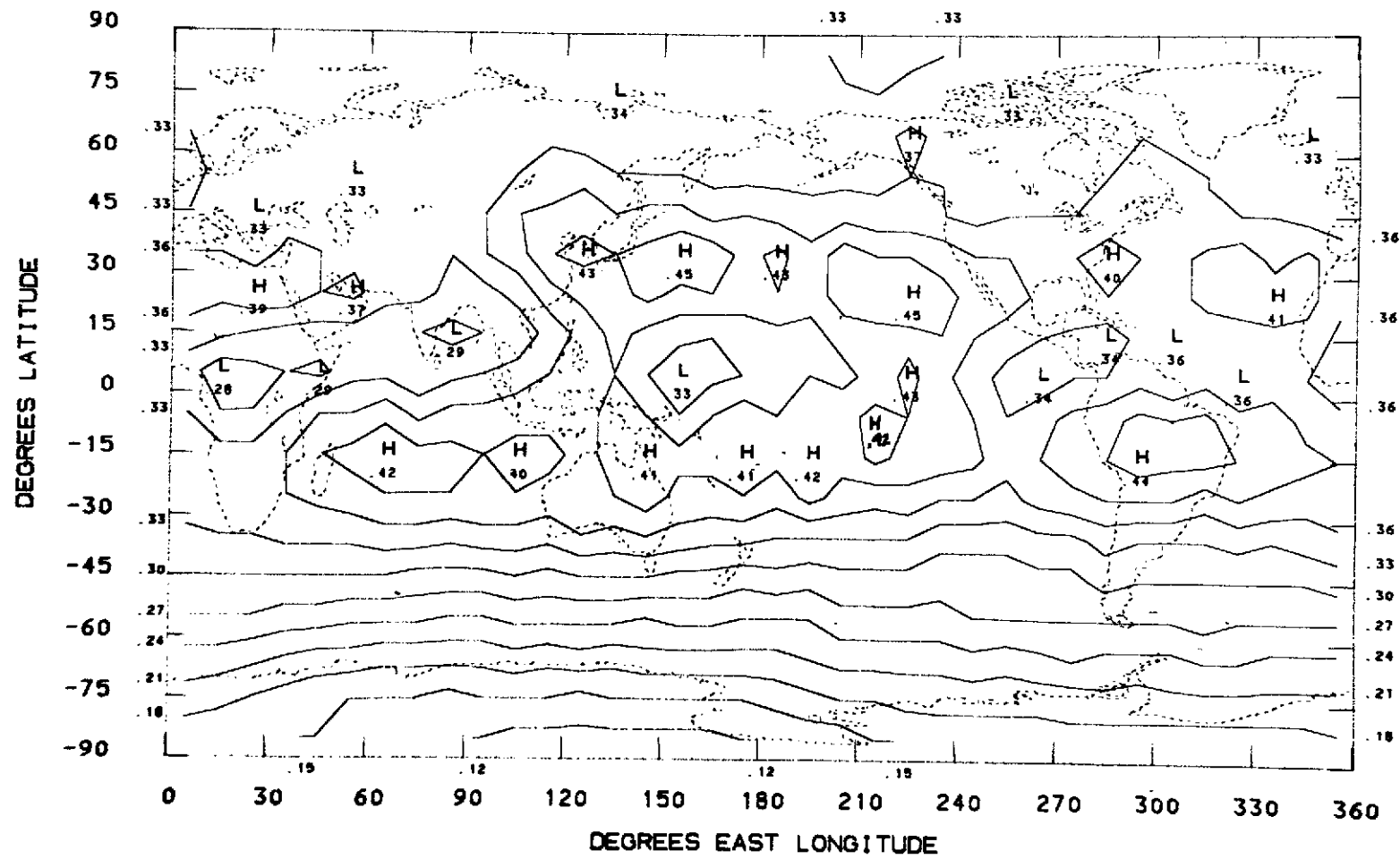
ABSORBED RADIATION (LY/MIN)
JUNE 1965



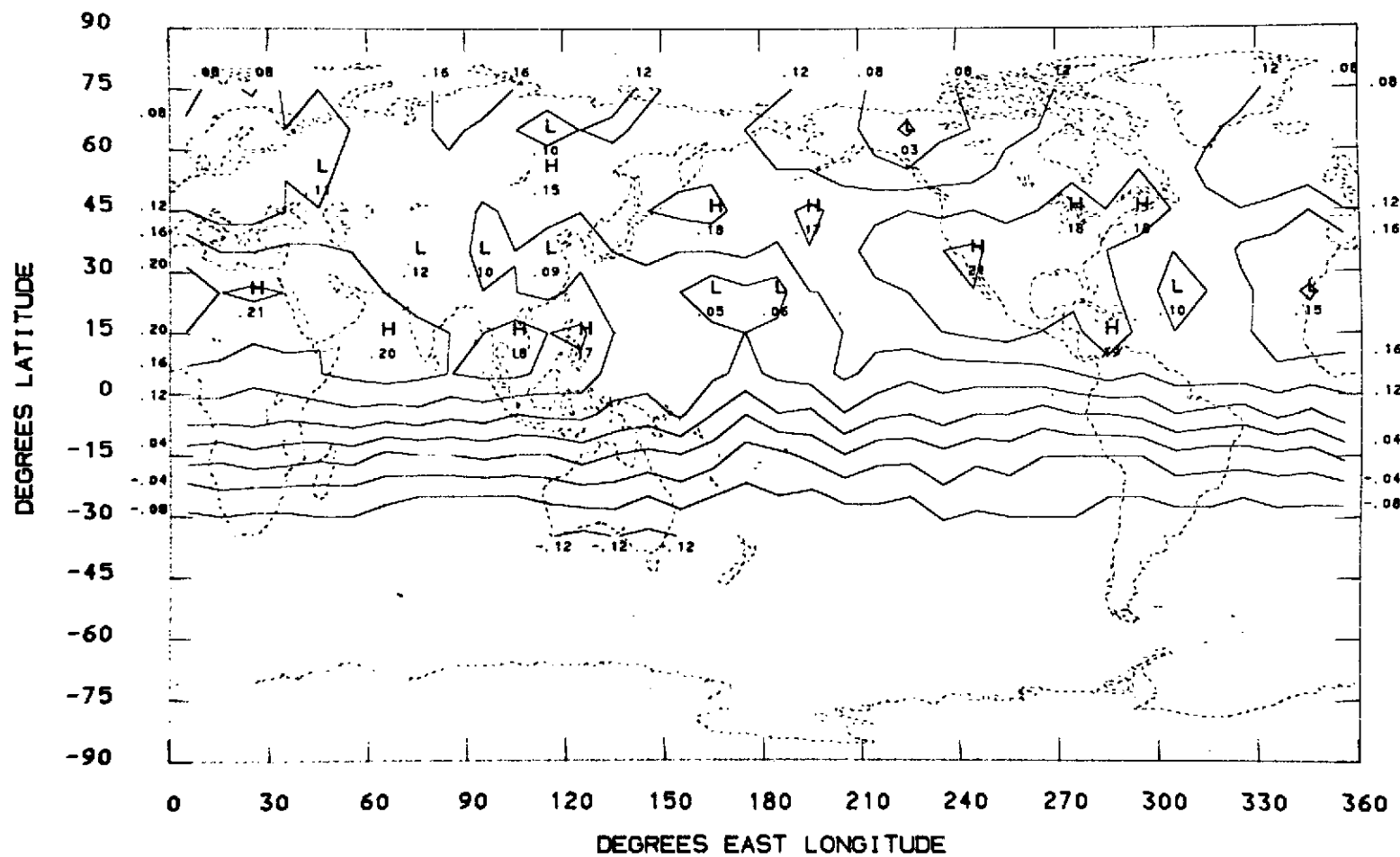
PLANETARY ALBEDO
JULY 1965



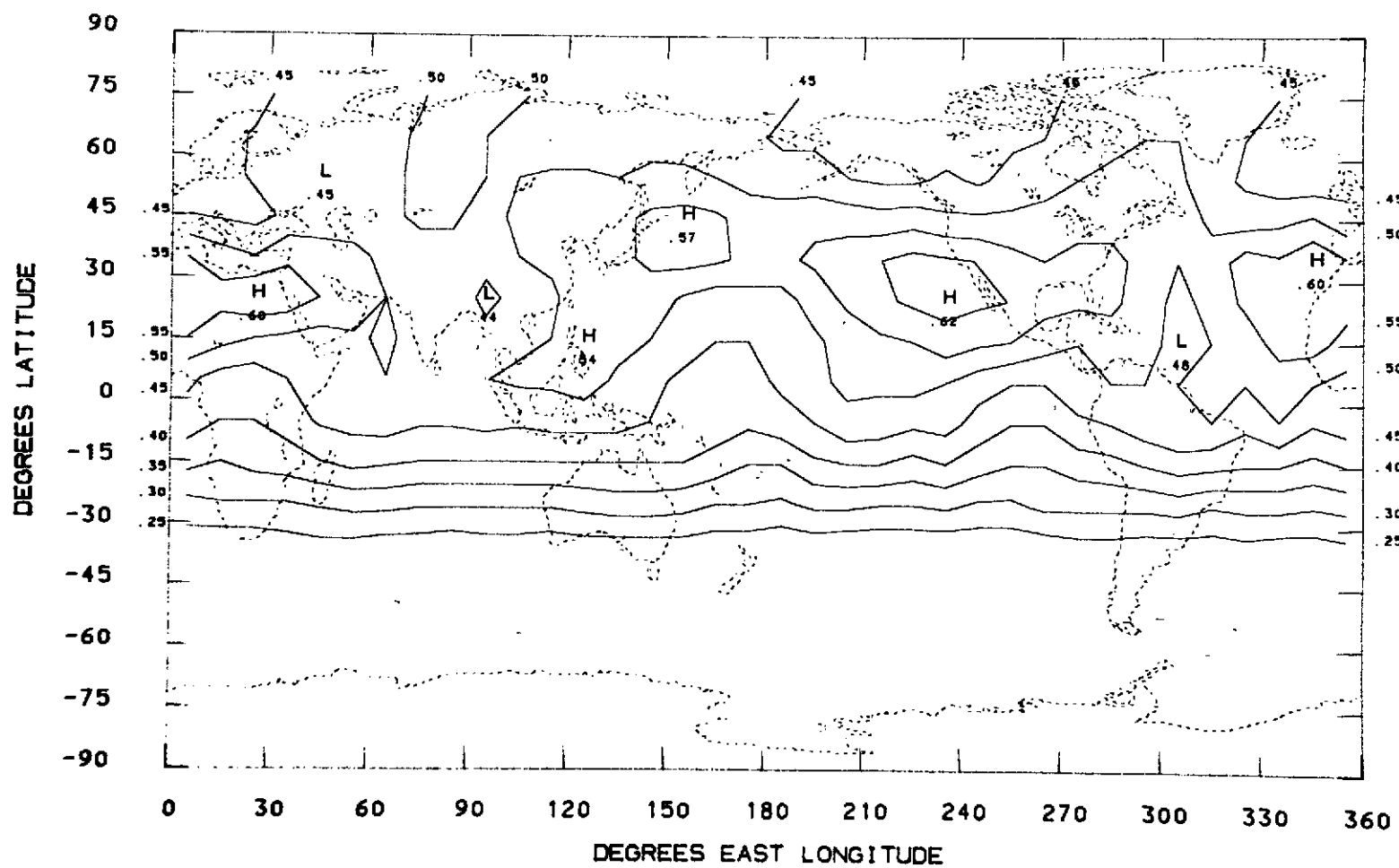
LONGWAVE RADIATION (LY/MIN)
JULY 1965



NET RADIATION (LY/MIN)
JULY 1965

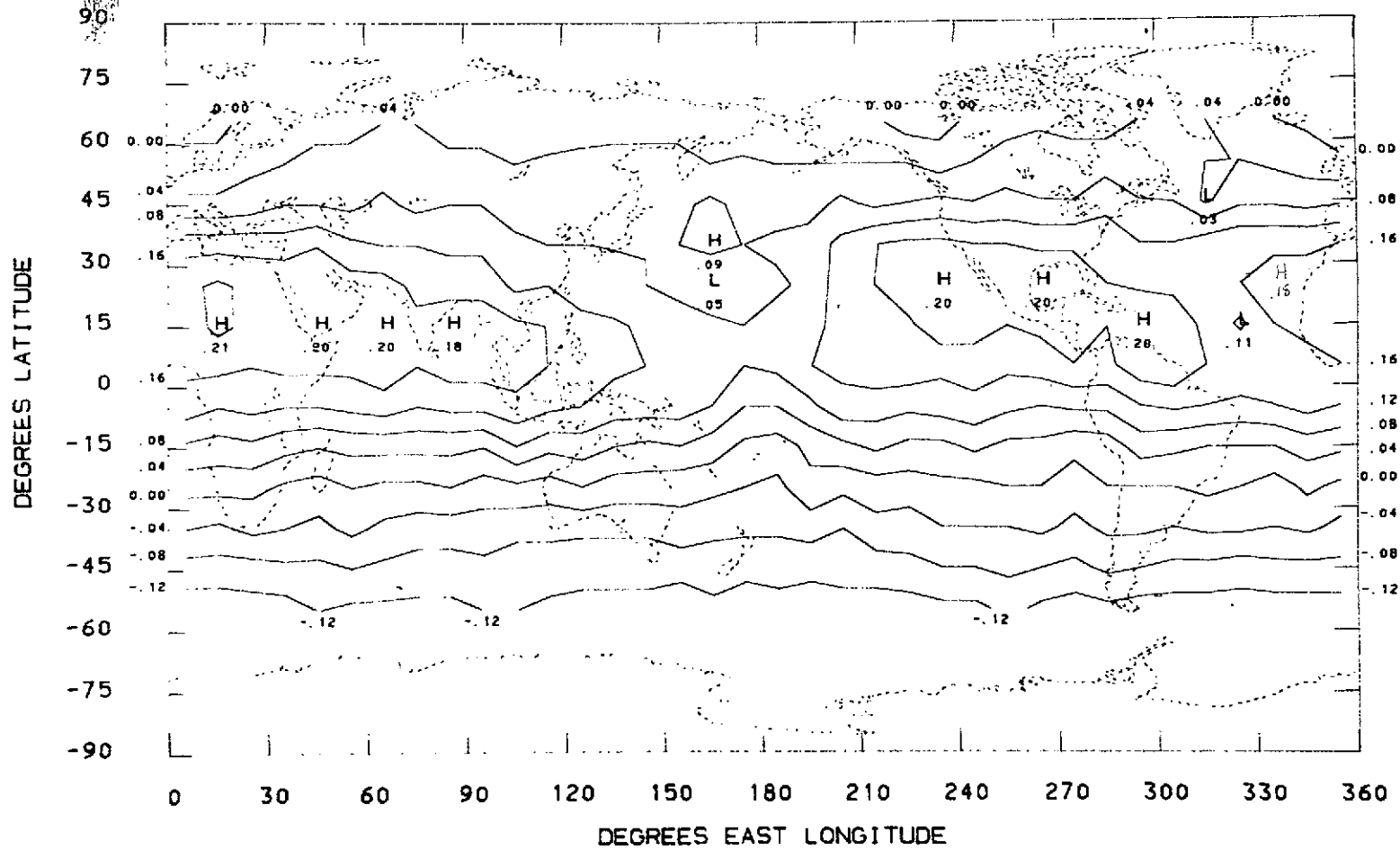


ABSORBED RADIATION (LY/MIN)
JULY 1965

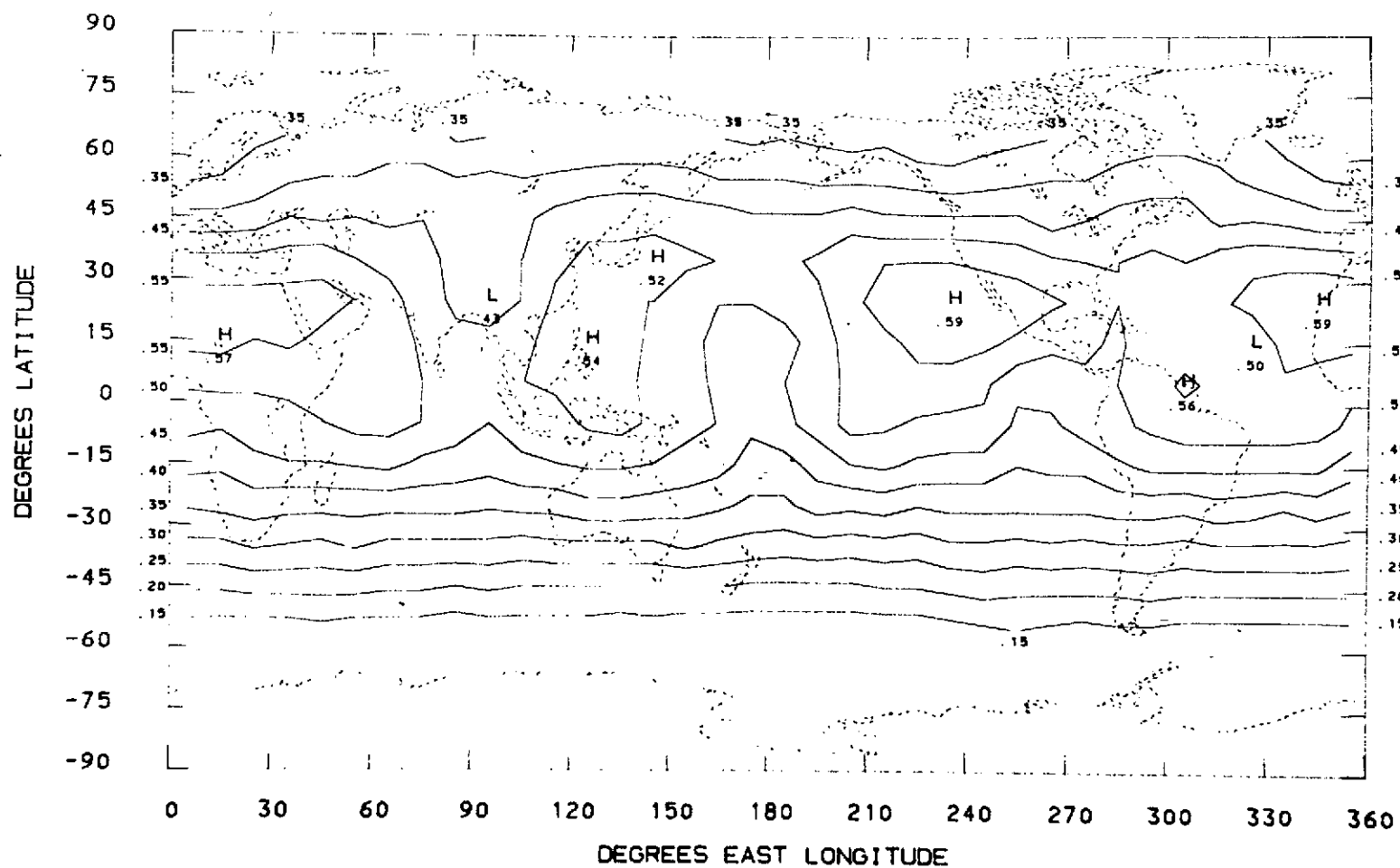


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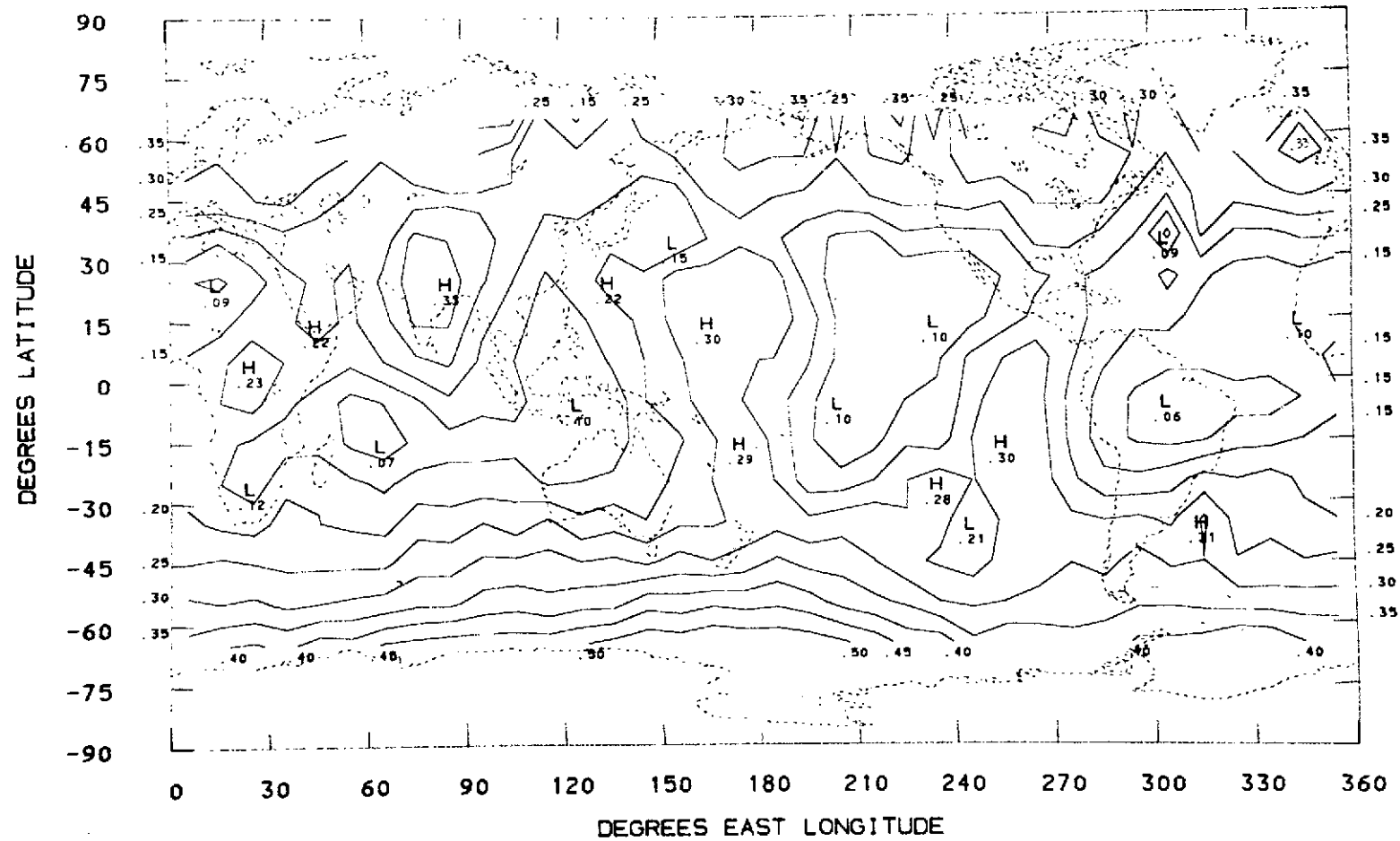
NET RADIATION (LY/MIN)
AUGUST 1965



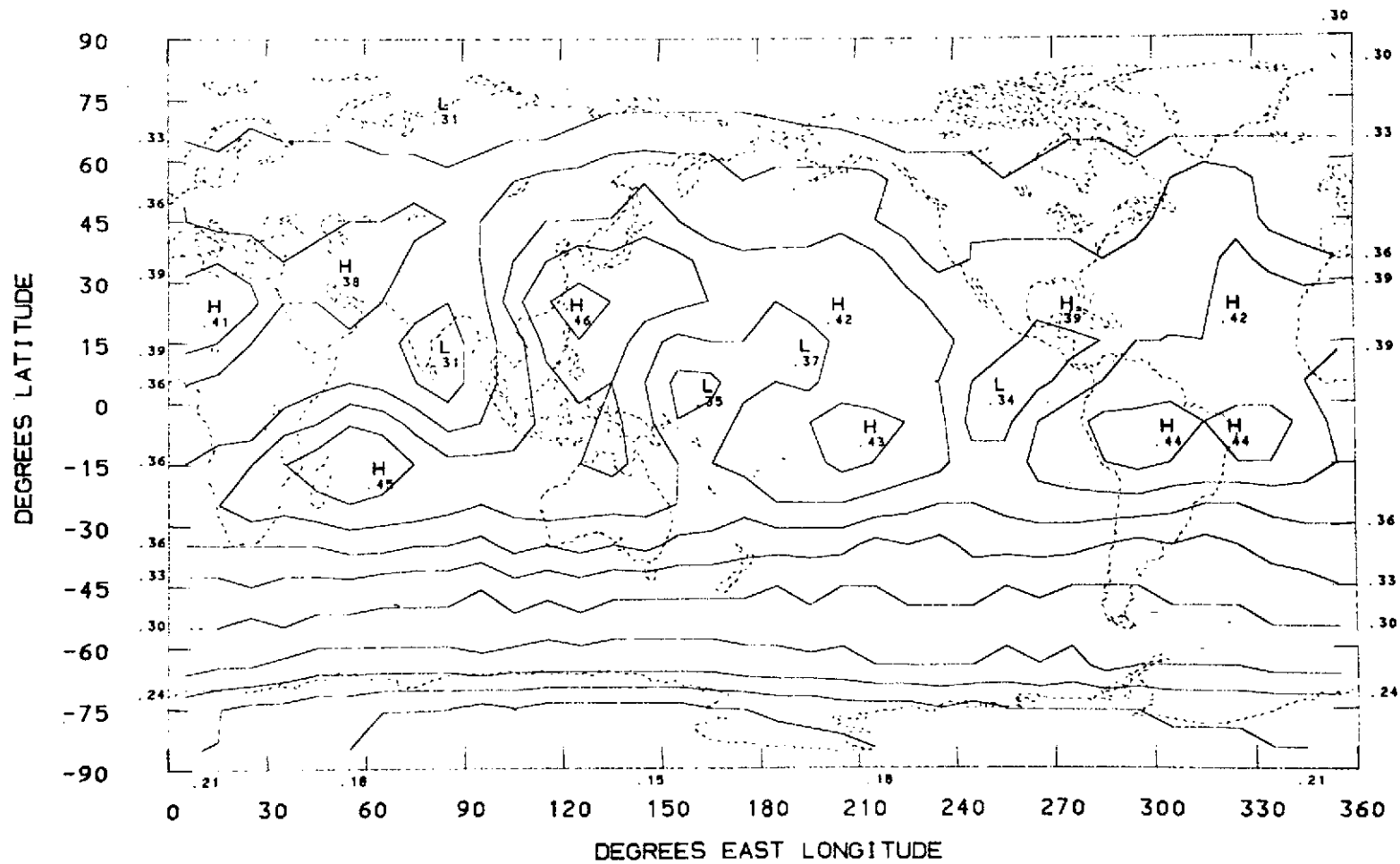
ABSORBED RADIATION (LY/MIN)
AUGUST 1965



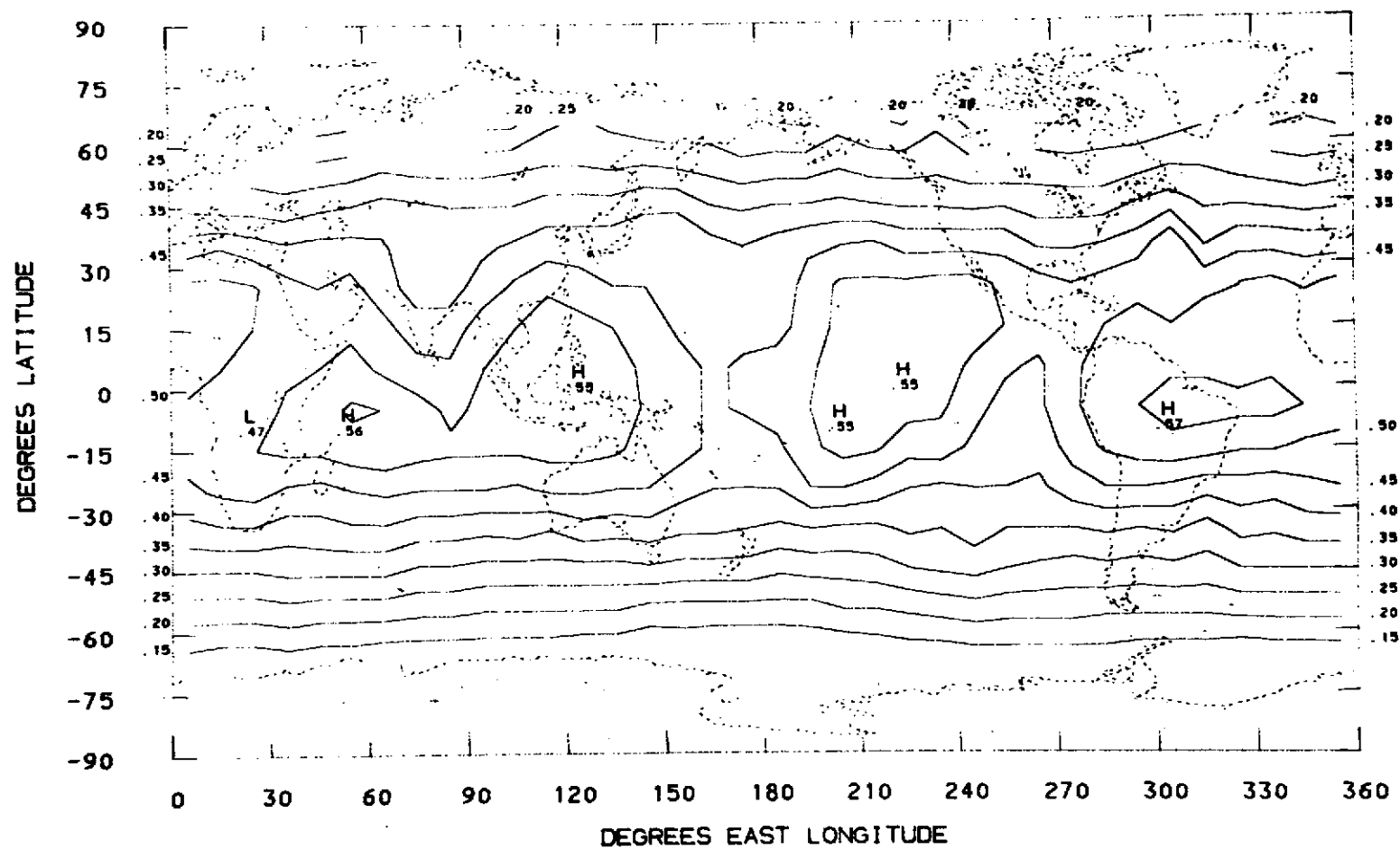
PLANETARY ALBEDO
SEPTEMBER 1965



LONGWAVE RADIATION (LY/MIN)
SEPTEMBER 1965

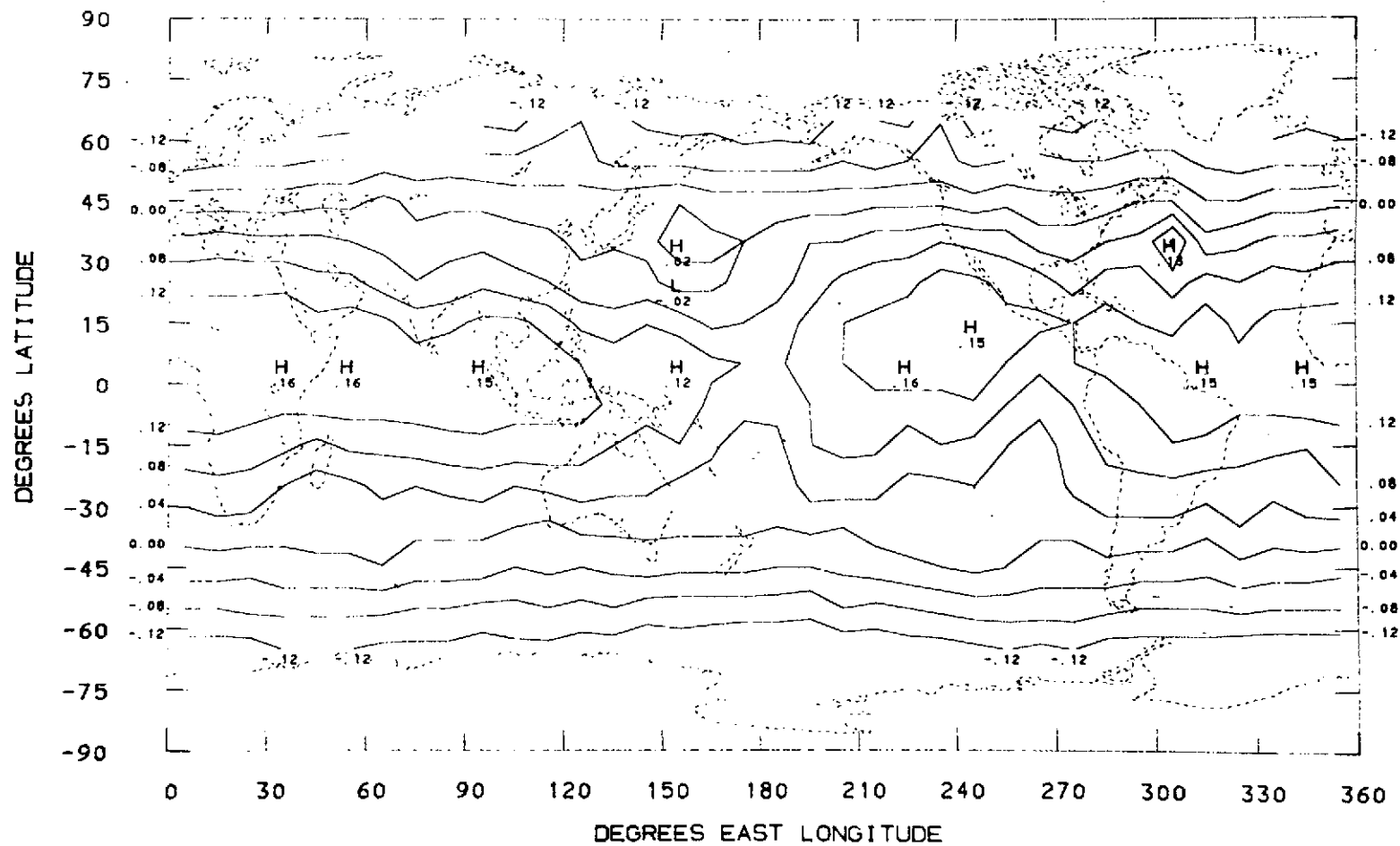


ABSORBED RADIATION (LY/MIN)
SEPTEMBER 1965



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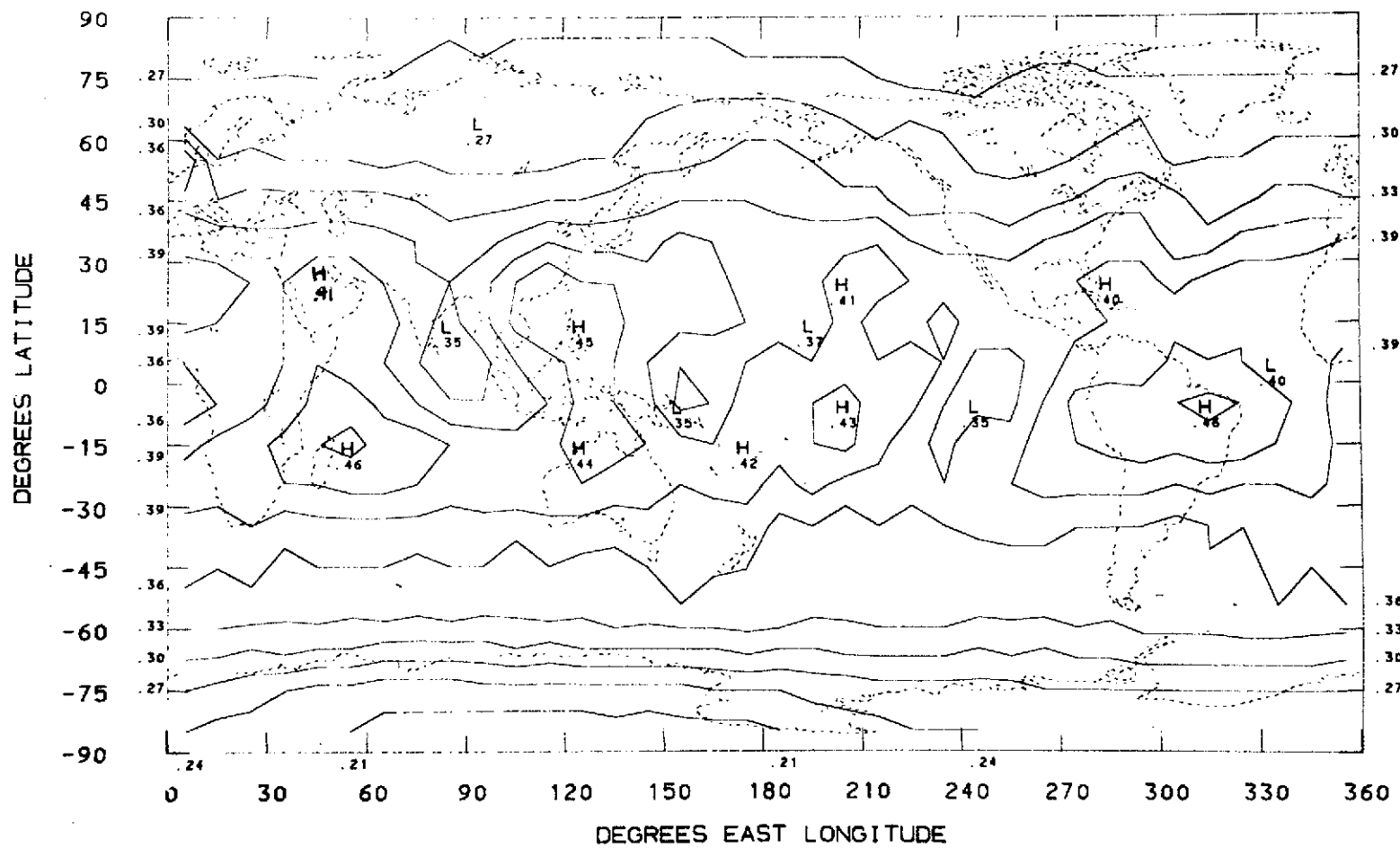
NET RADIATION (LY/MIN)
SEPTEMBER 1965



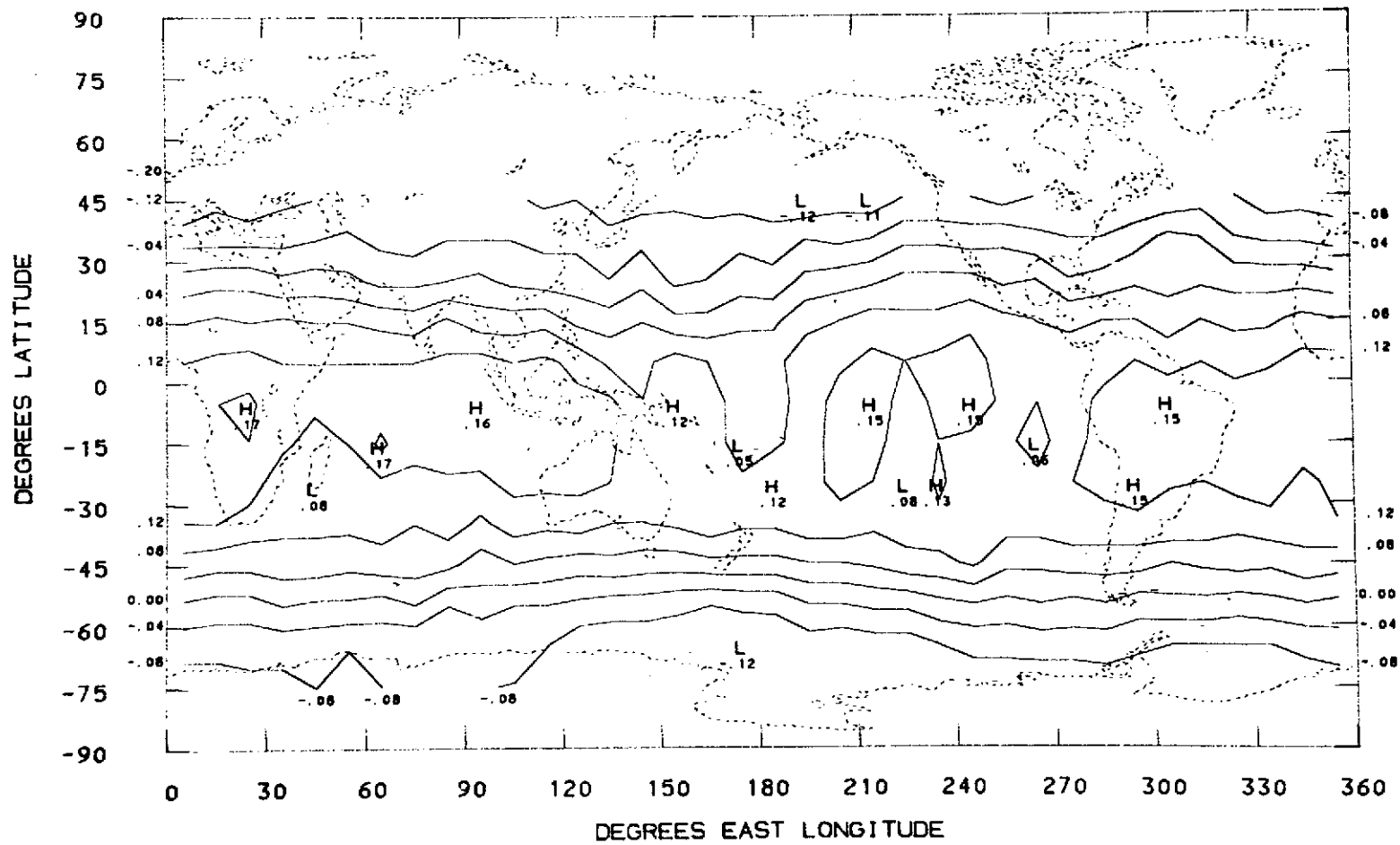
PLANETARY ALBEDO
OCTOBER 1965



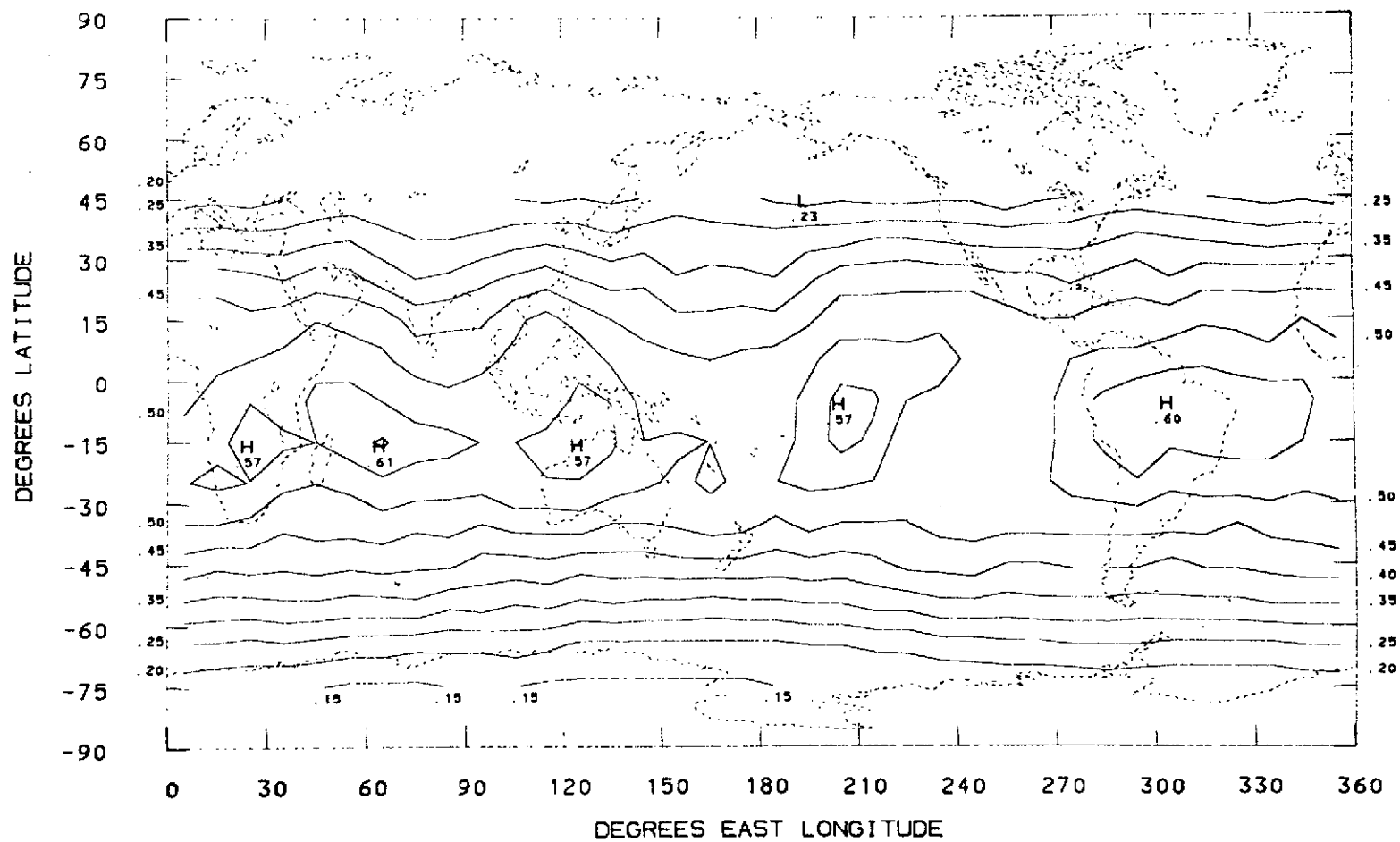
LONGWAVE RADIATION (LY/MIN)
OCTOBER 1965



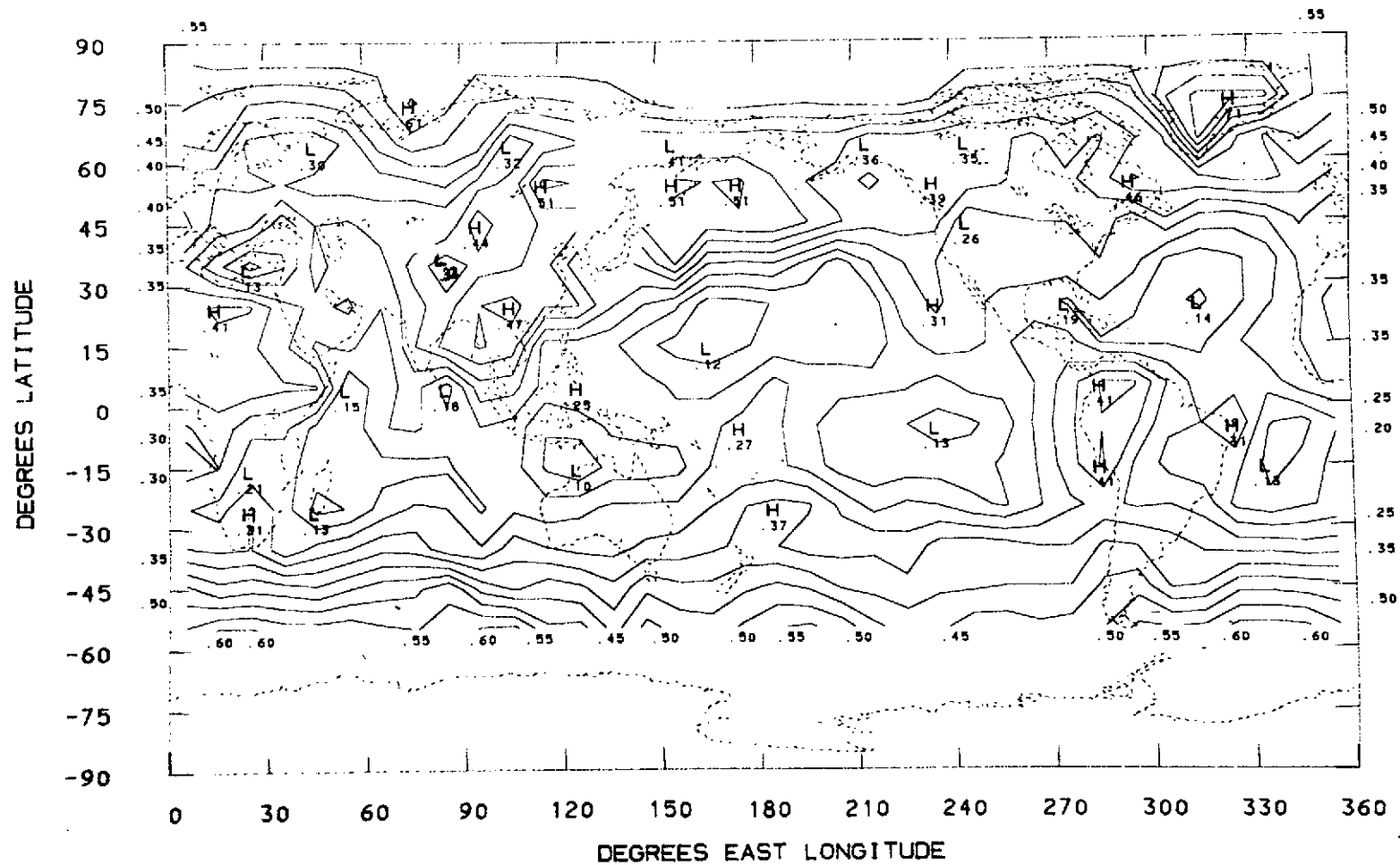
NET RADIATION (LY/MIN)
OCTOBER 1965



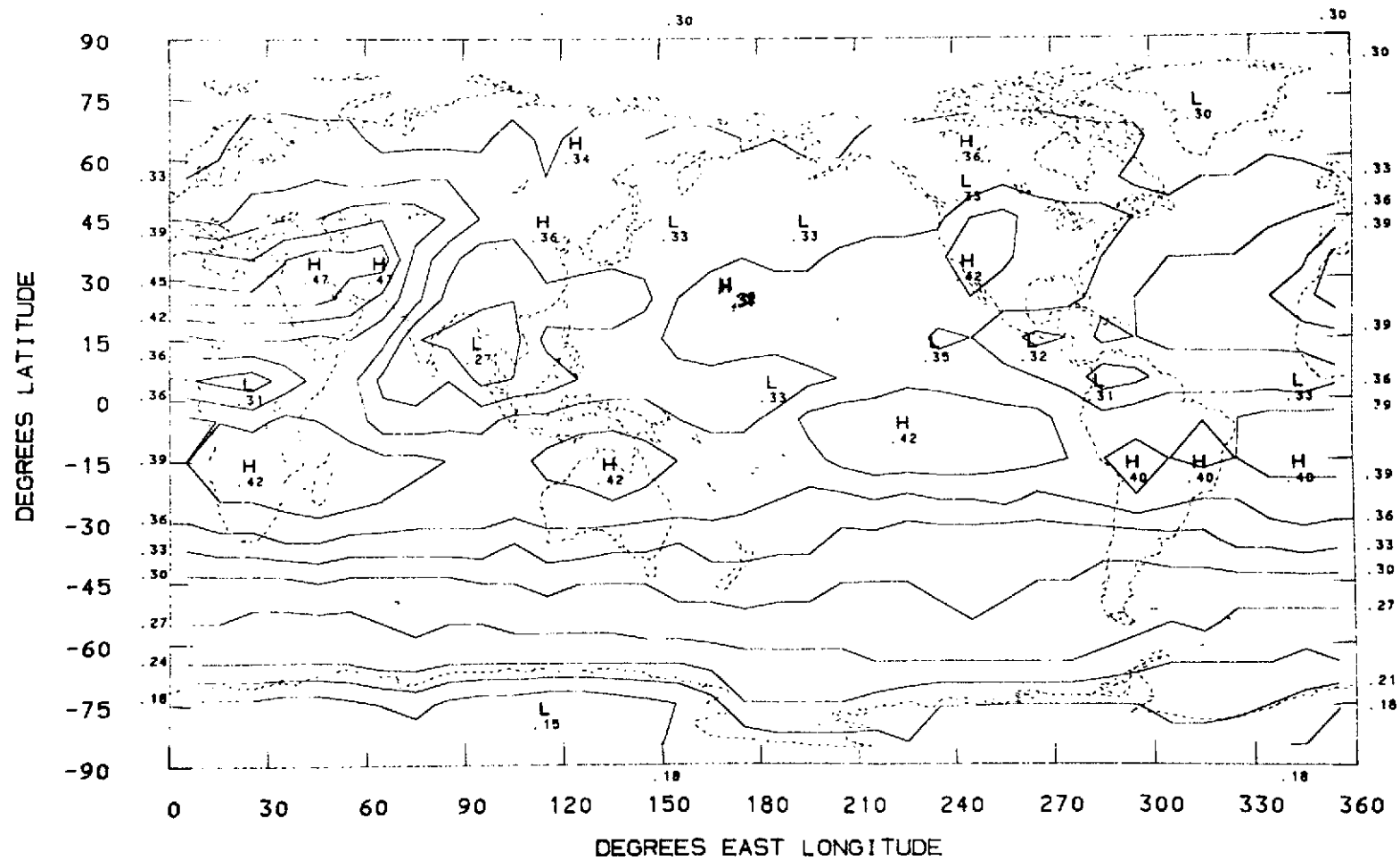
ABSORBED RADIATION (LY/MIN)
OCTOBER 1965



PLANETARY ALBEDO
JULY 1966

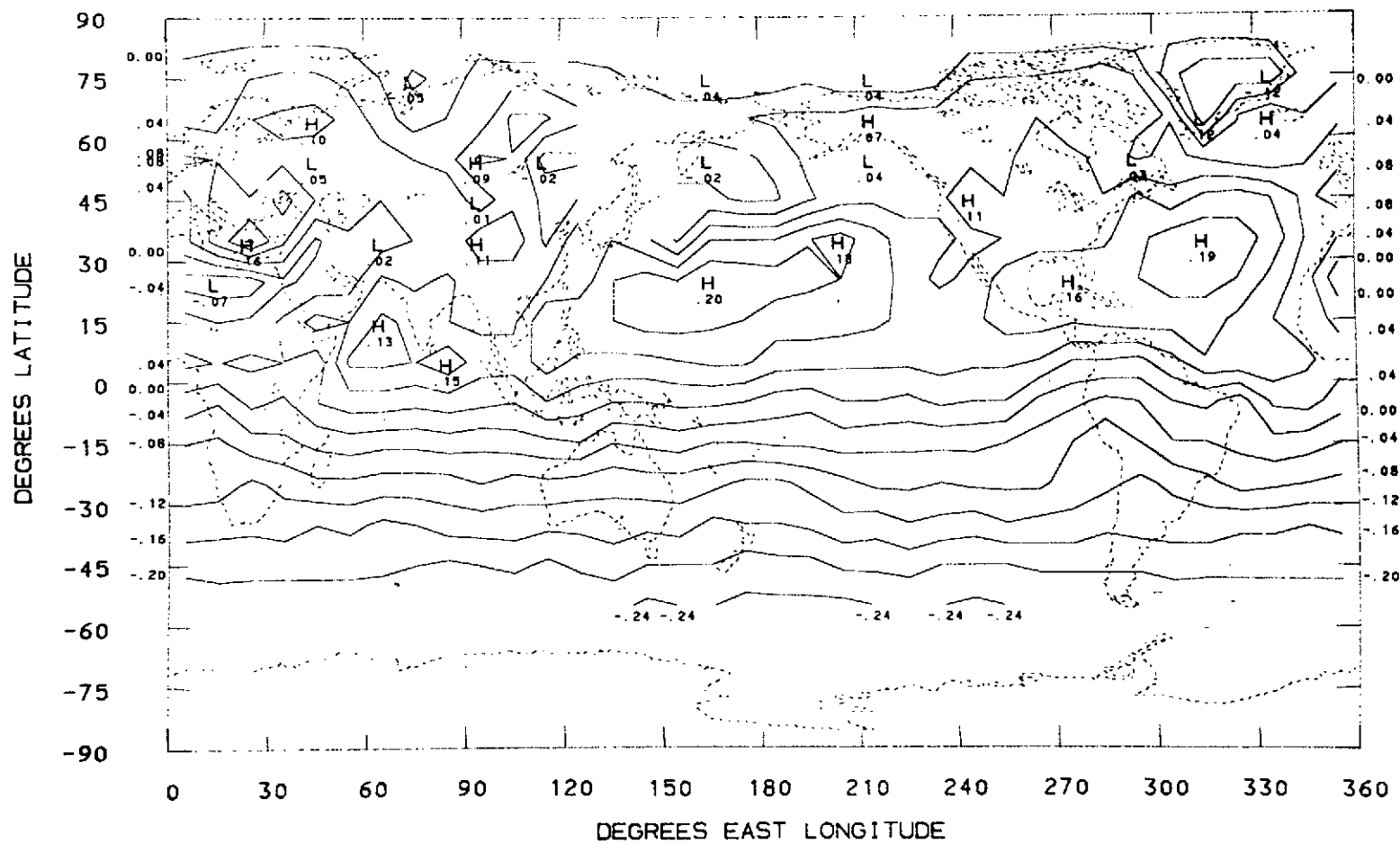


LONGWAVE RADIATION (LY/MIN)
JULY 1966

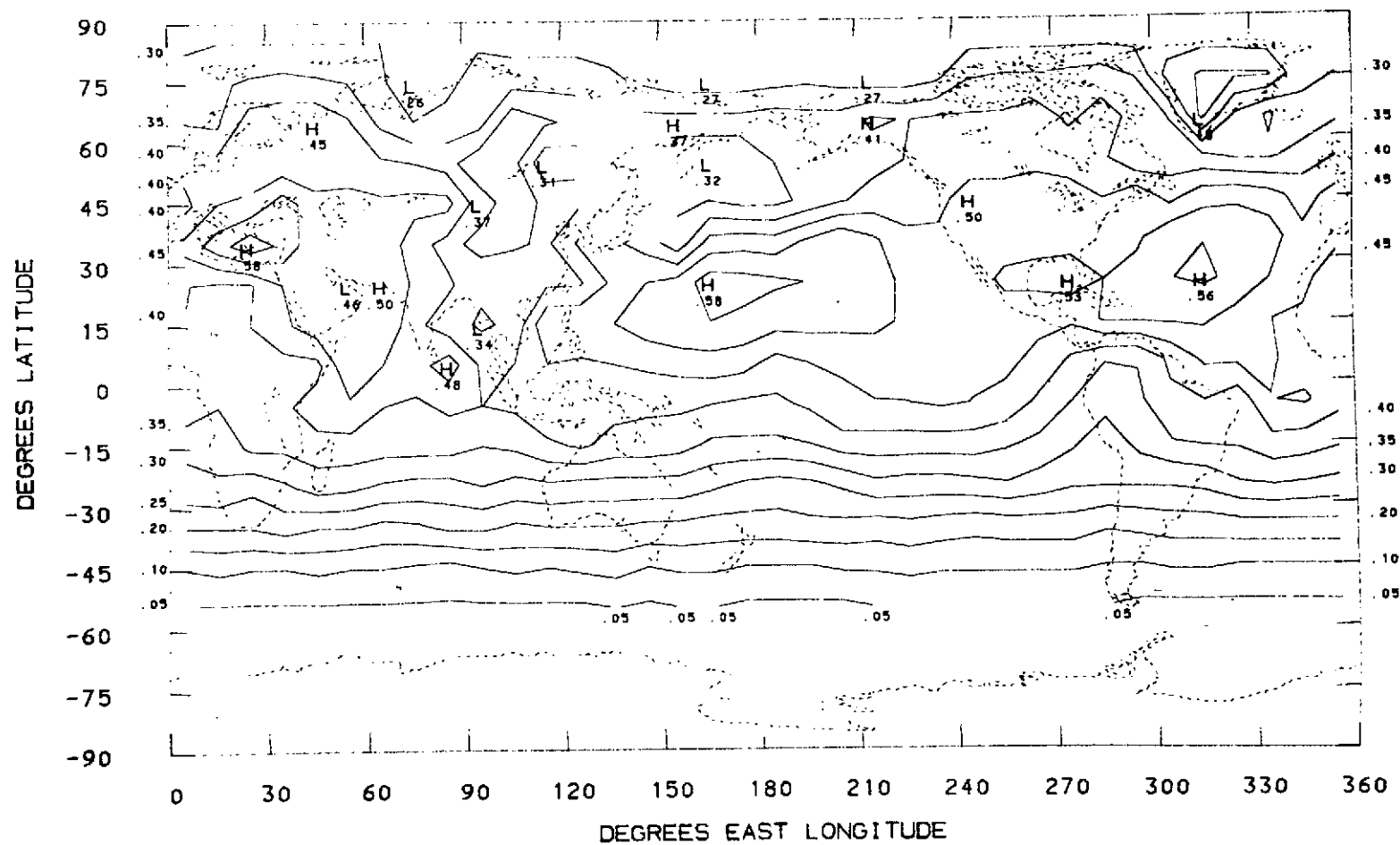


NET RADIATION (LY/MIN)

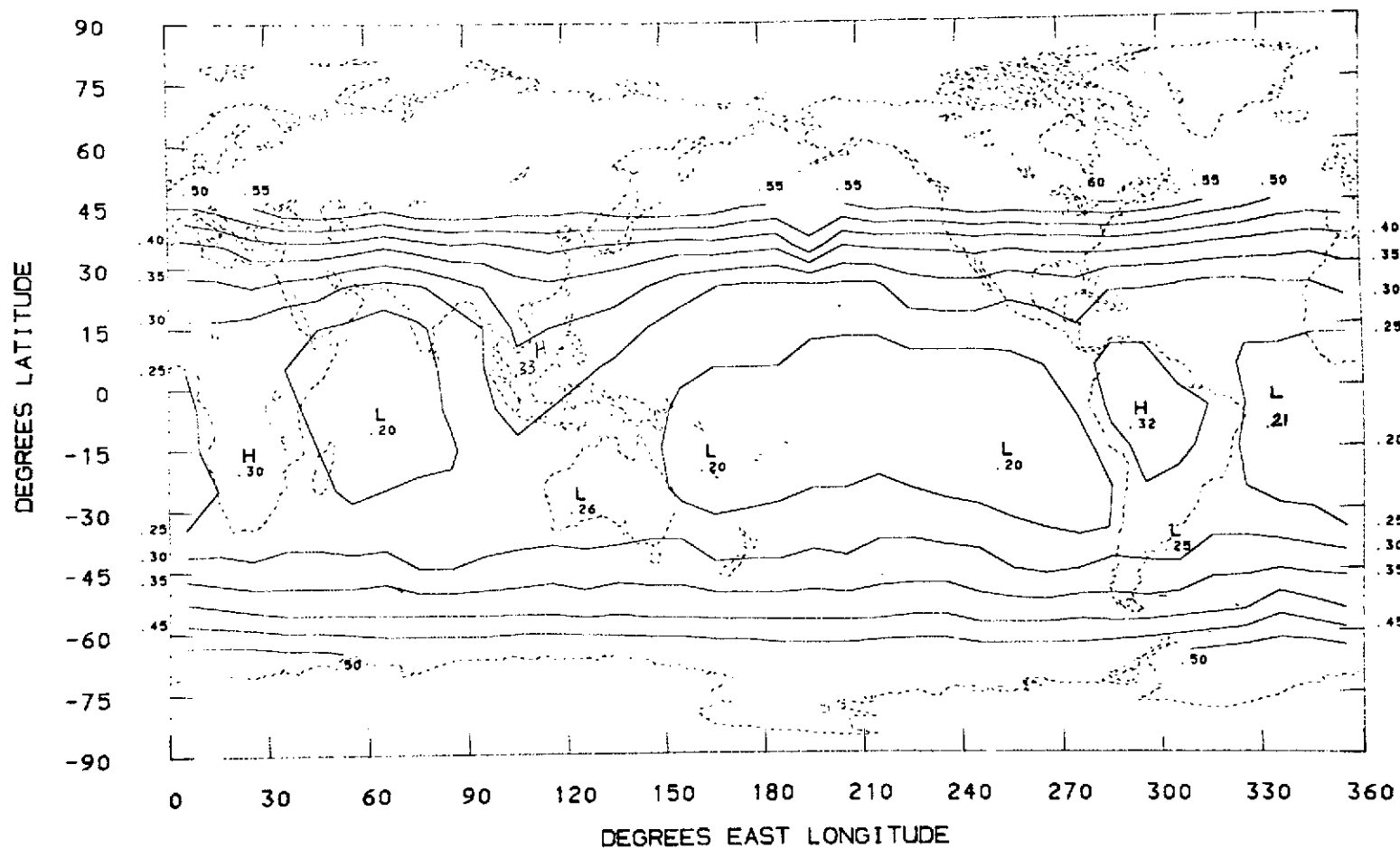
JULY 1966



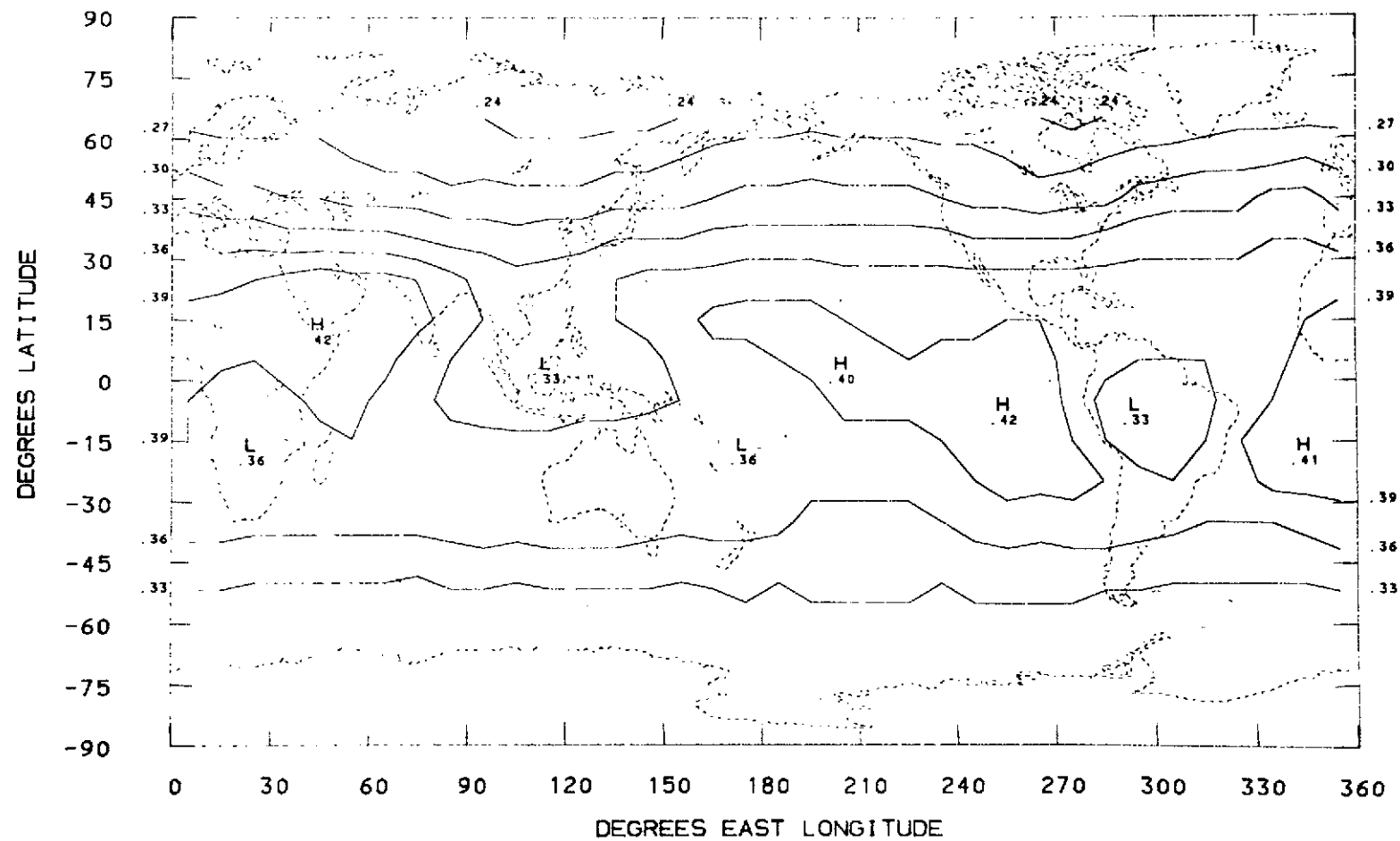
ABSORBED RADIATION (LY/MIN)
JULY 1966



PLANETARY ALBEDO
DECEMBER 1966

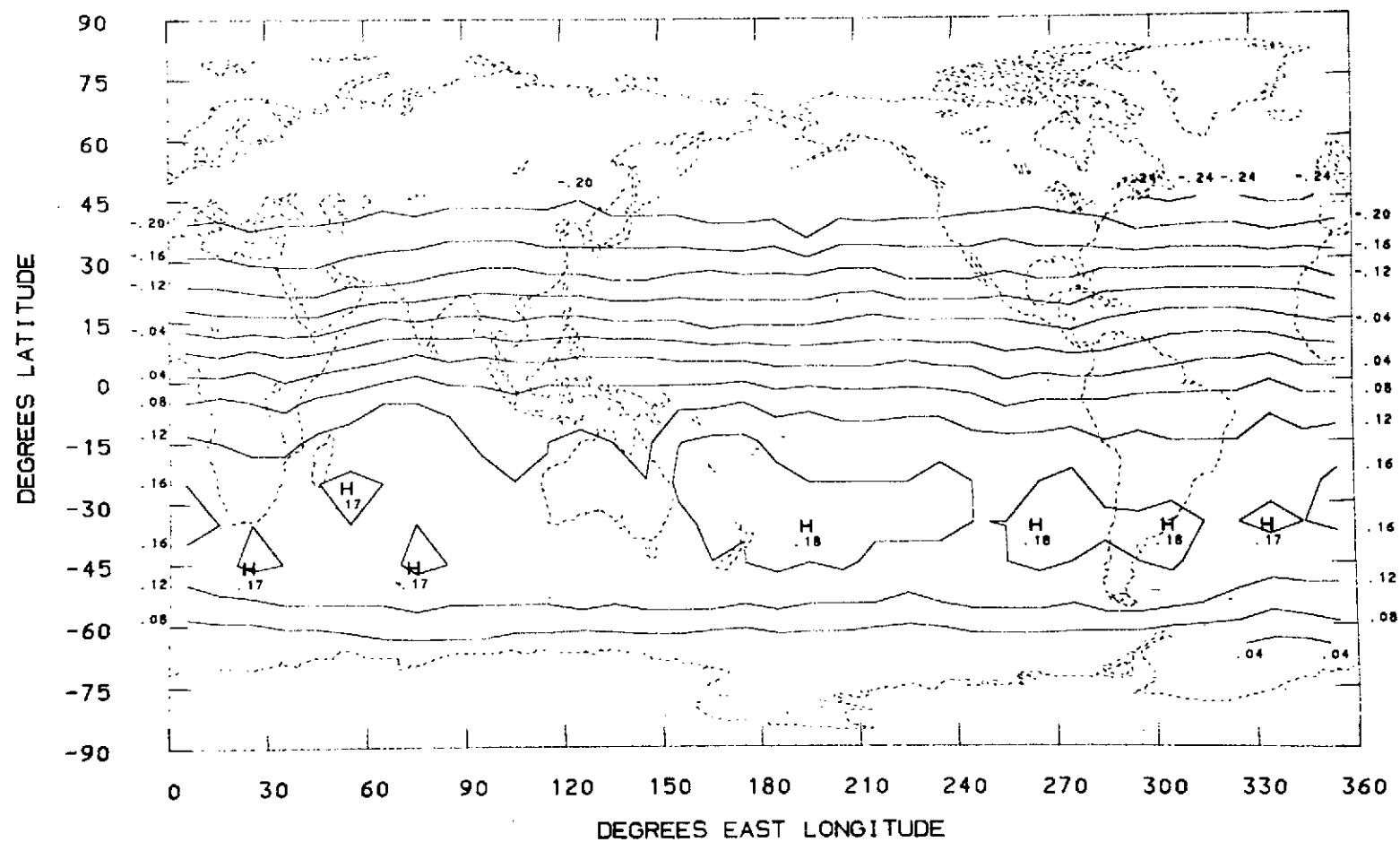


LONGWAVE RADIATION (LY/MIN)
DECEMBER 1966

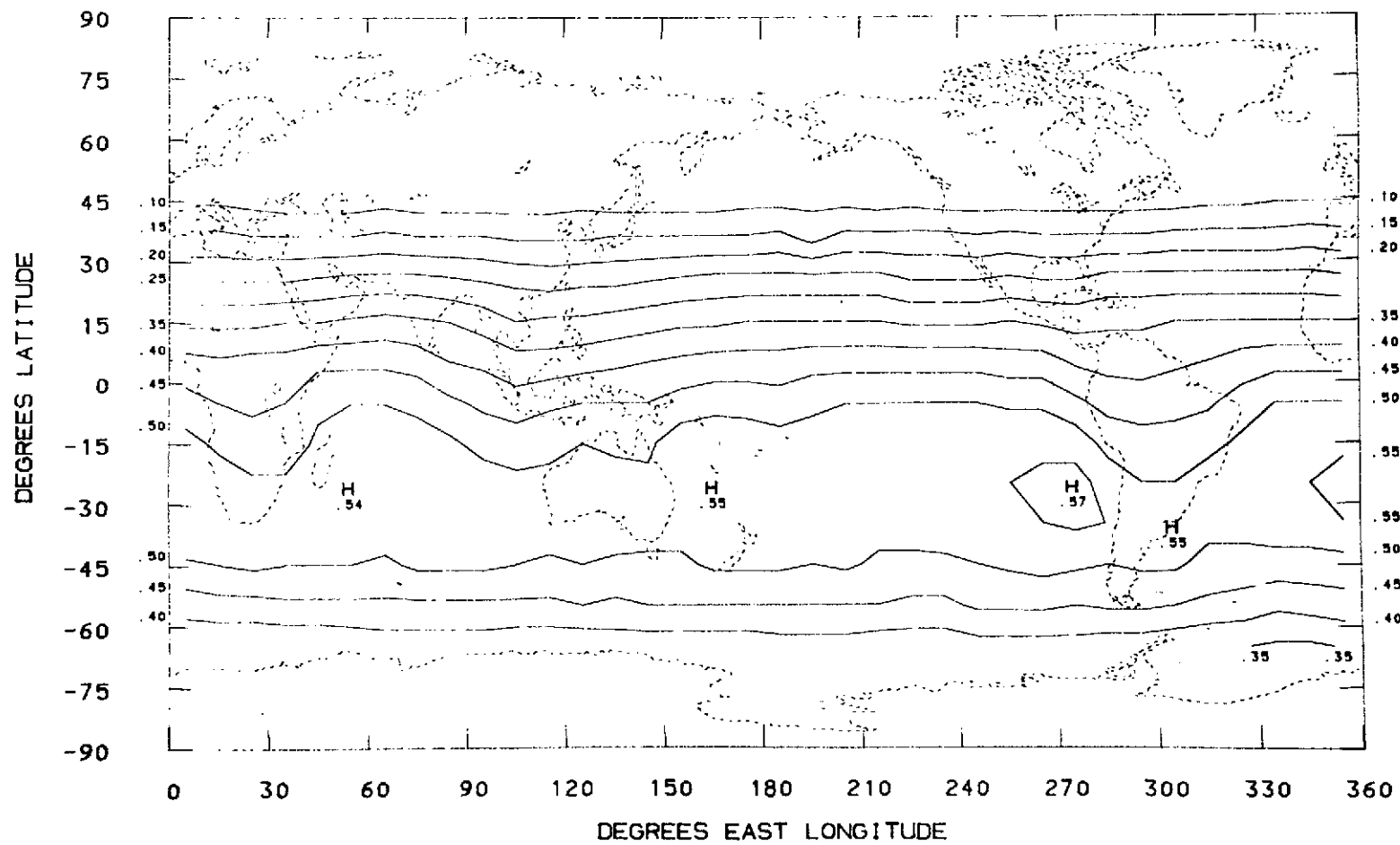


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NET RADIATION (LY/MIN)
DECEMBER 1966

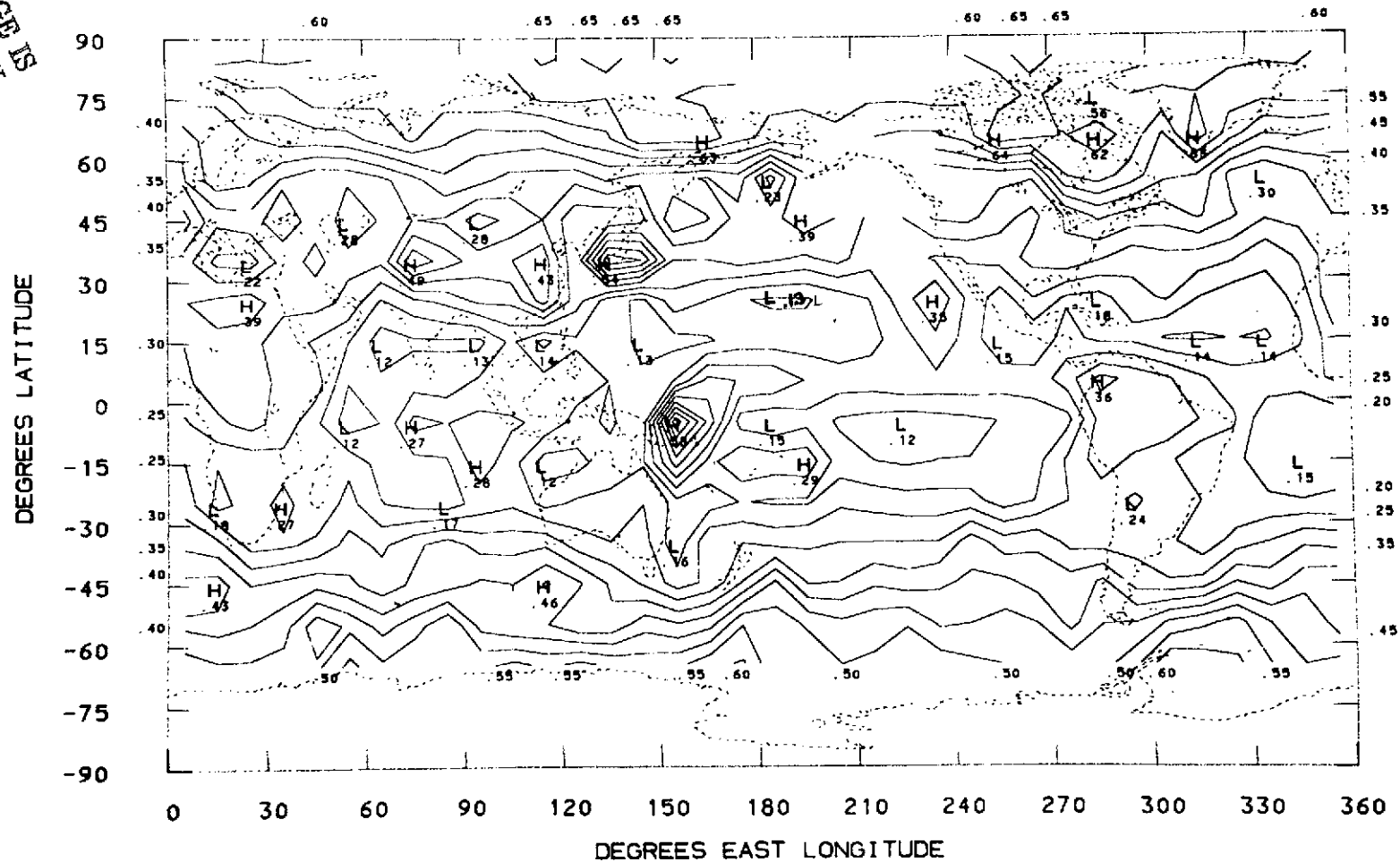


ABSORBED RADIATION (LY/MIN)
DECEMBER 1966

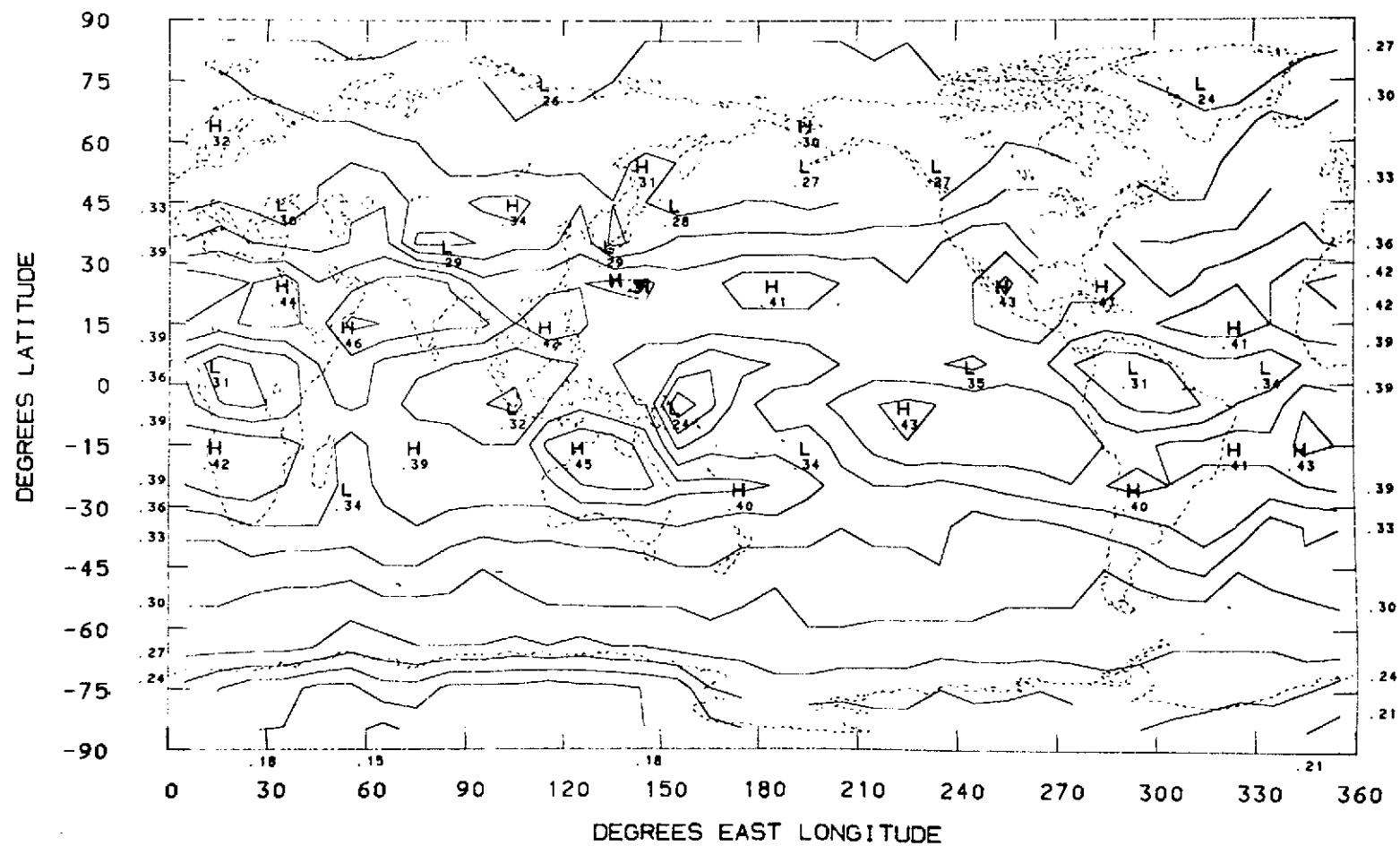


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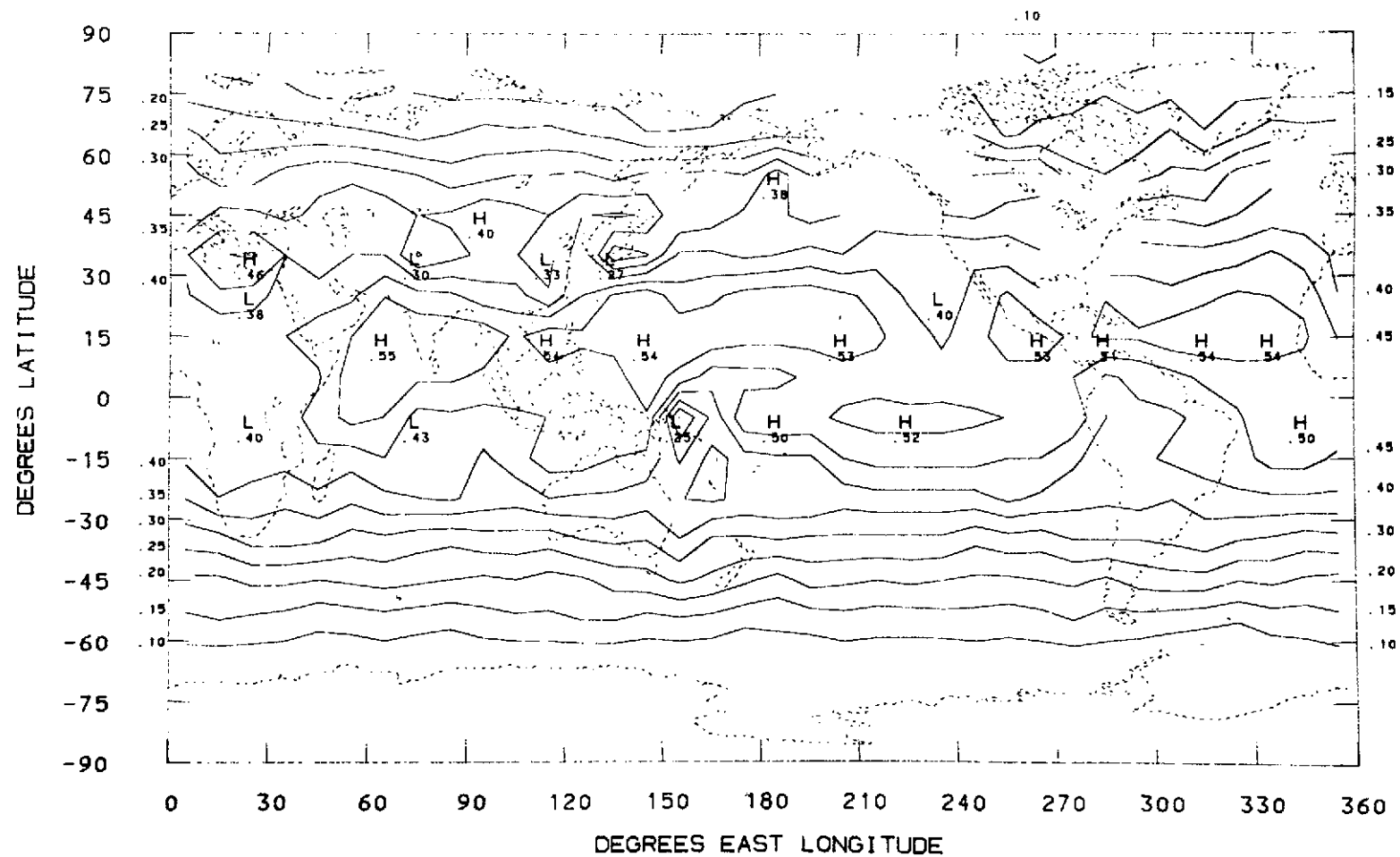
PLANETARY ALBEDO
APRIL 1969



LONGWAVE RADIATION (LY/MIN)
APRIL 1969

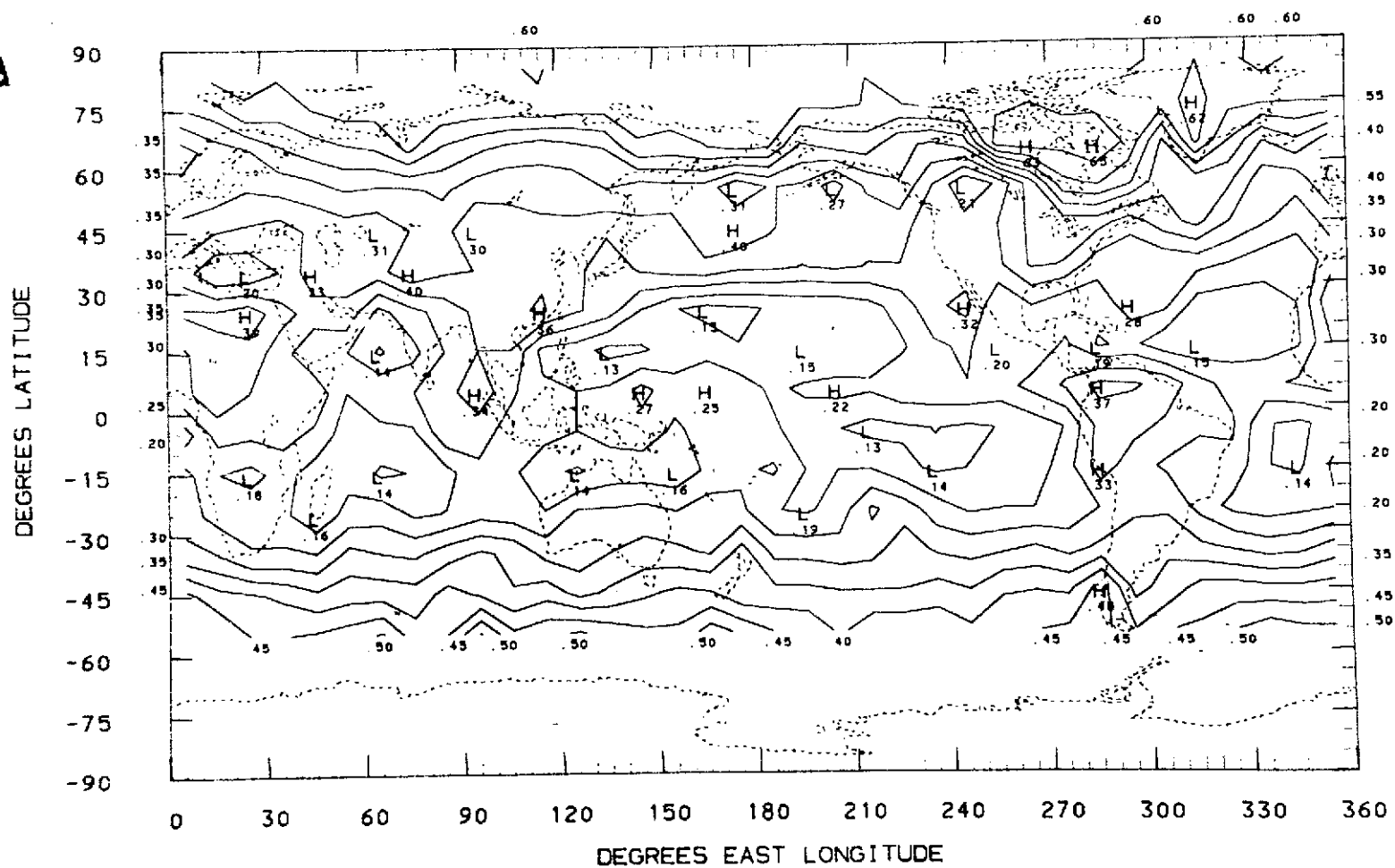


ABSORBED RADIATION (LY/MIN)
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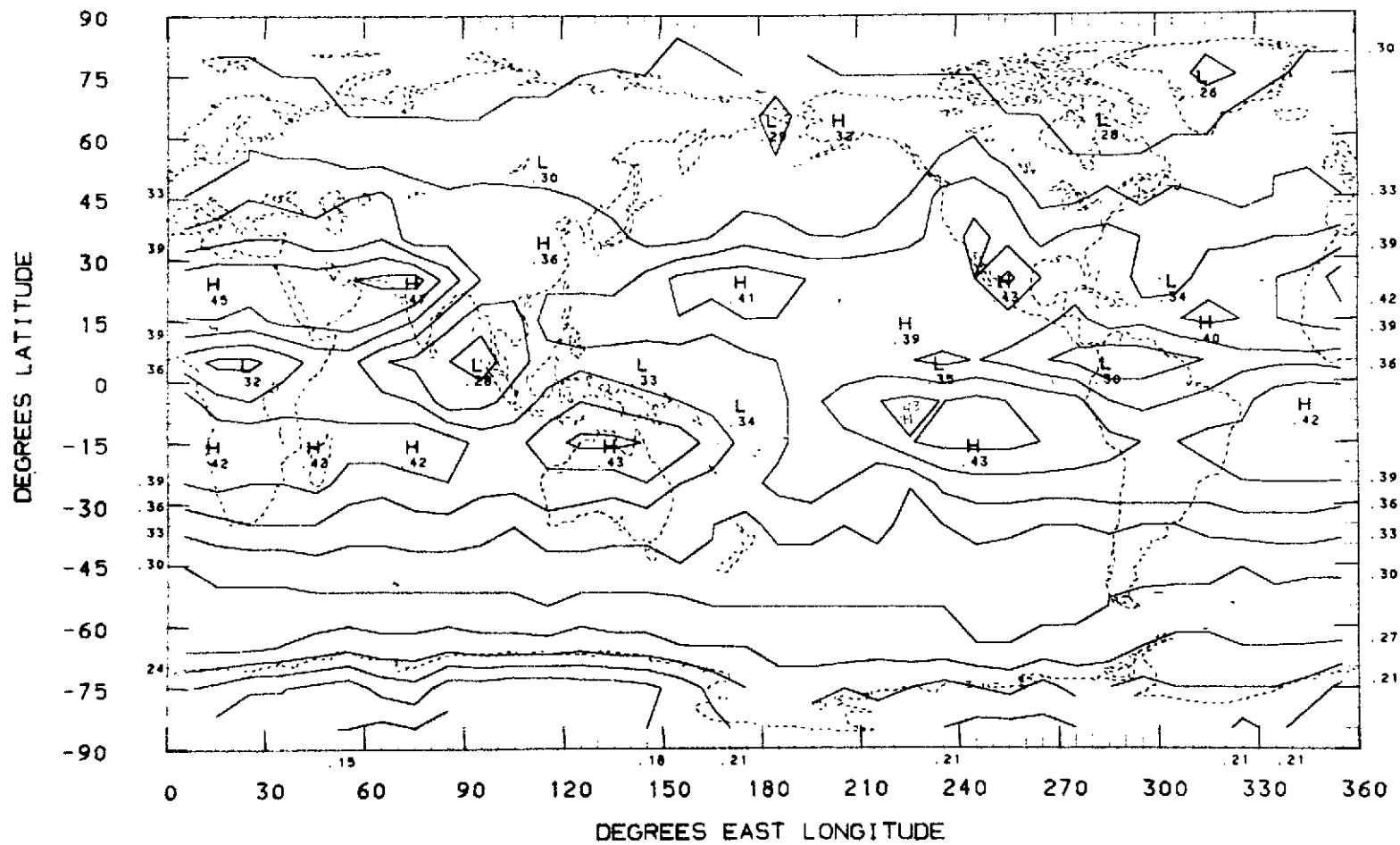


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PLANETARY ALBEDO
MAY (1-15) 1969

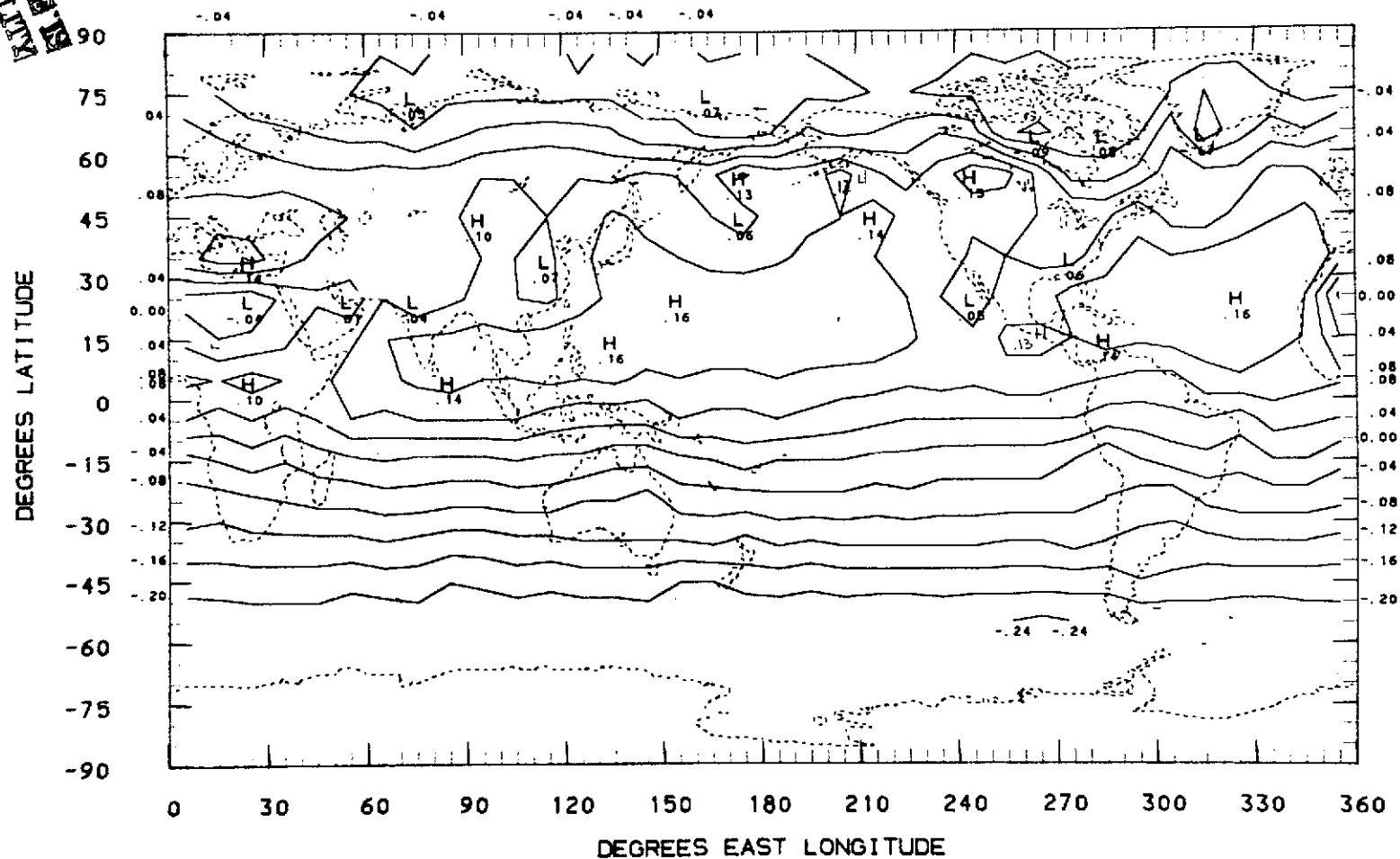


LONGWAVE RADIATION (LY/MIN)
MAY(1-15) 1969

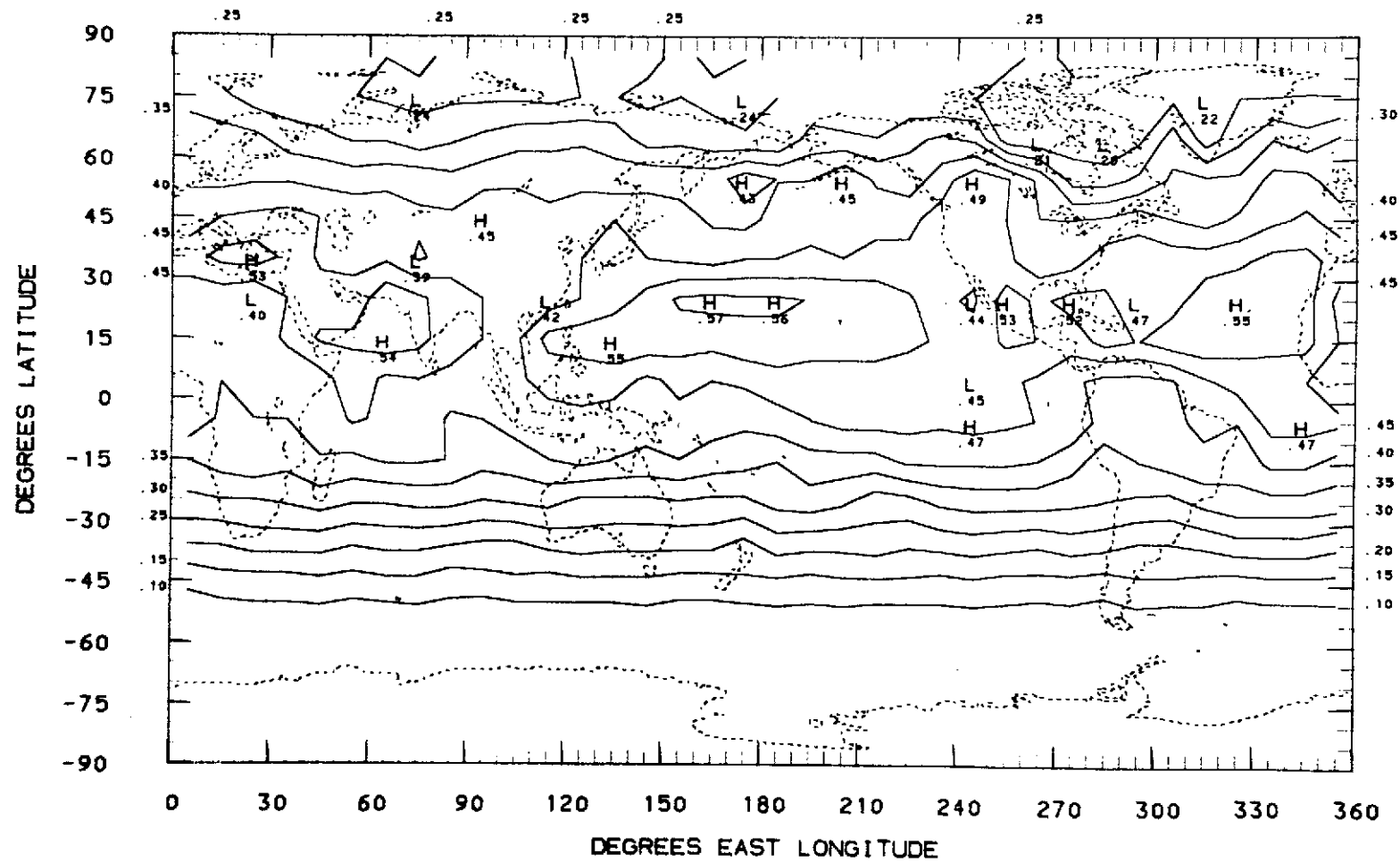


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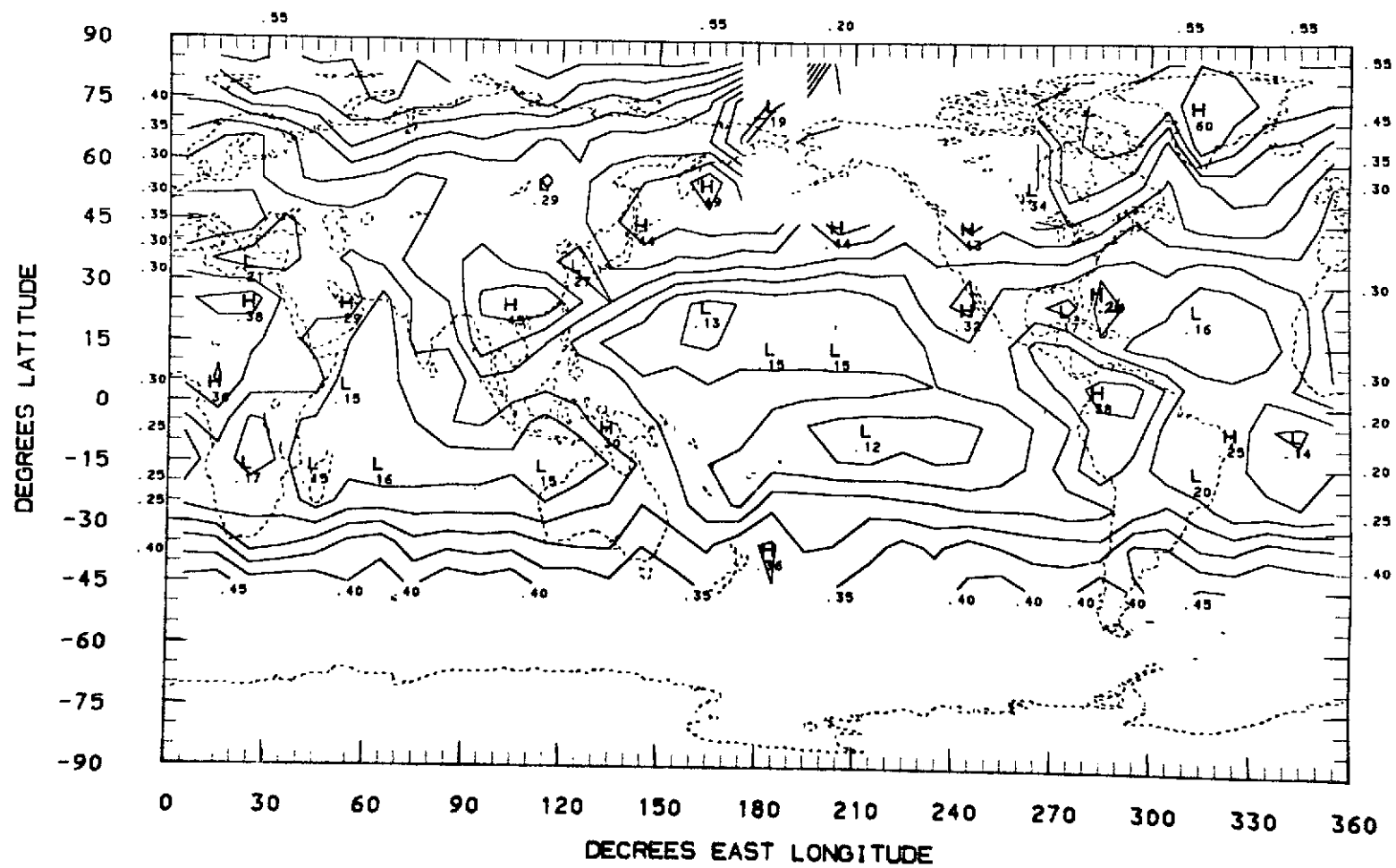
NET RADIATION (LY/MIN)
MAY(1-15) 1969



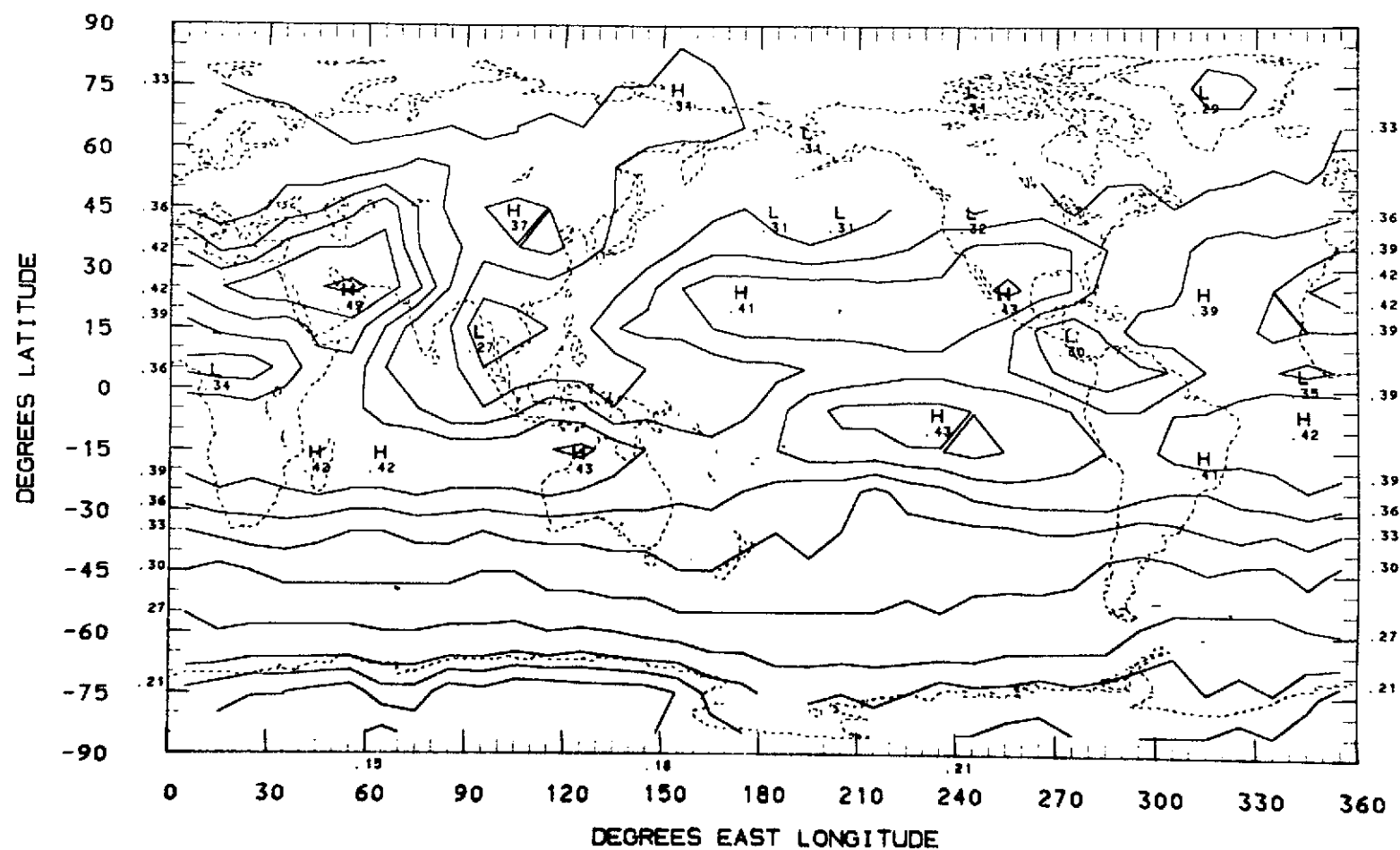
ABSORBED RADIATION (LY/MIN)
MAY(1-15) 1969



PLANETARY ALBEDO
JUNE 1969

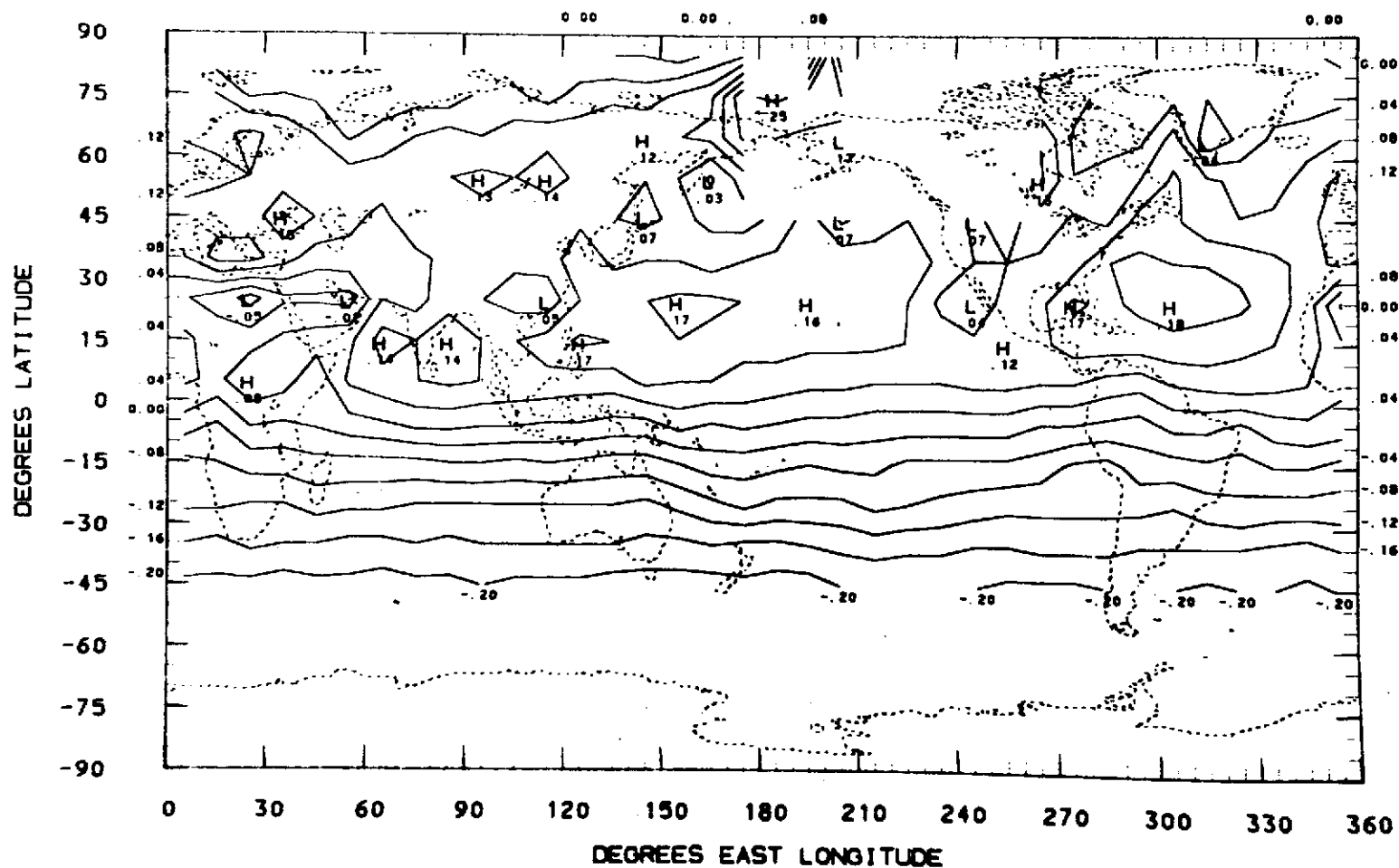


LONGWAVE RADIATION (LY/MIN)
JUNE 1969

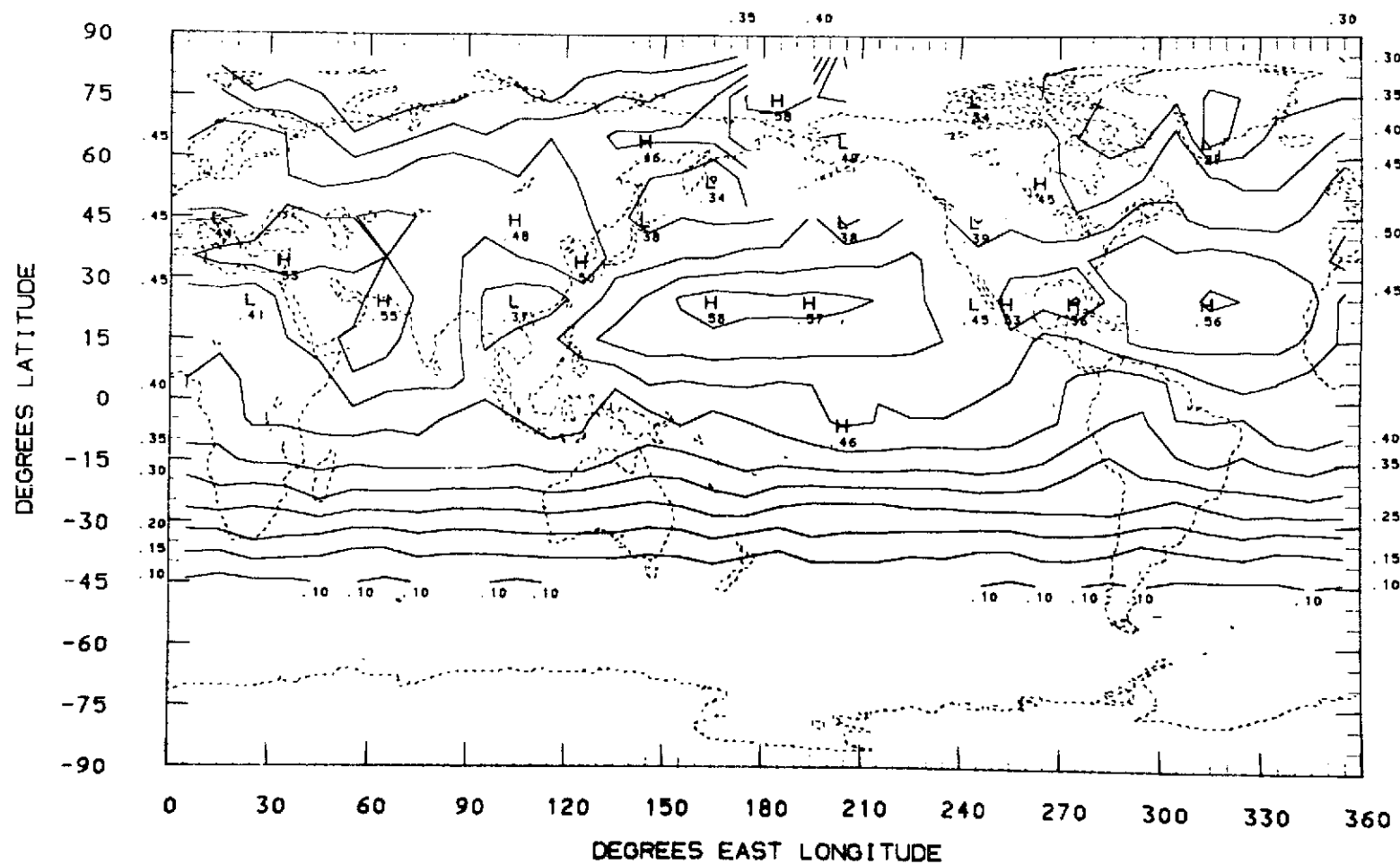


NET RADIATION (LY/MIN)

JUNE 1969

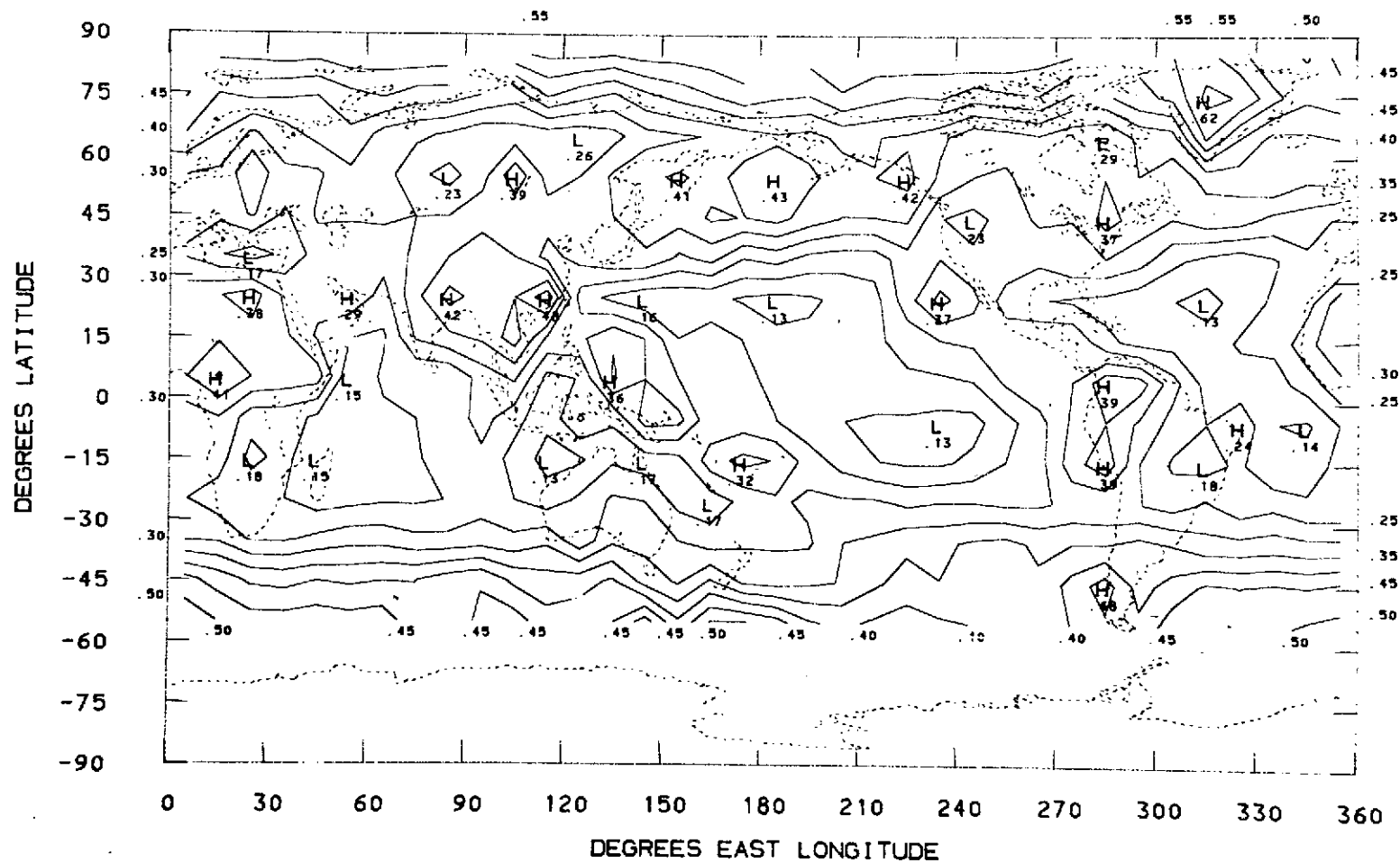


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JUNE 1969

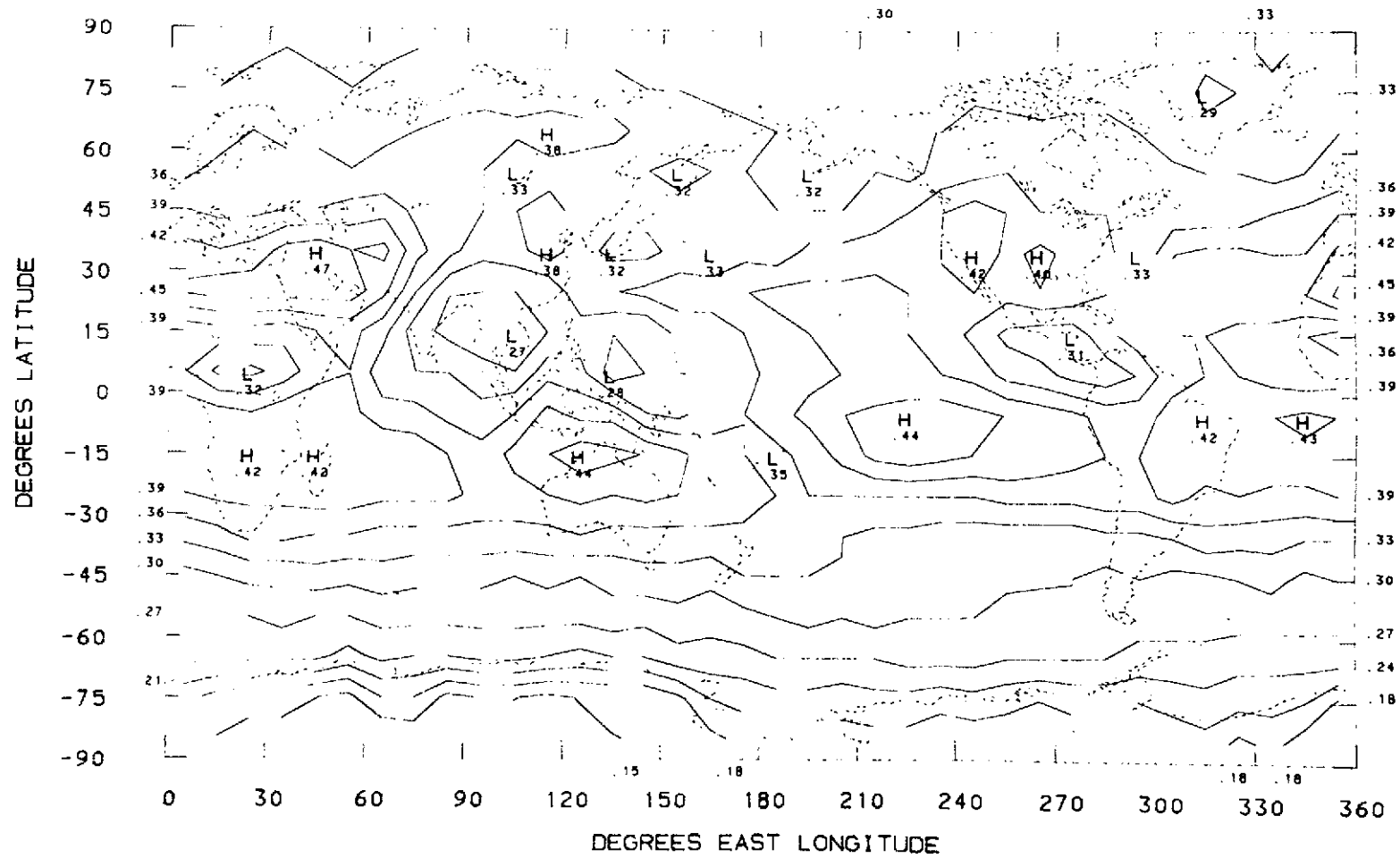


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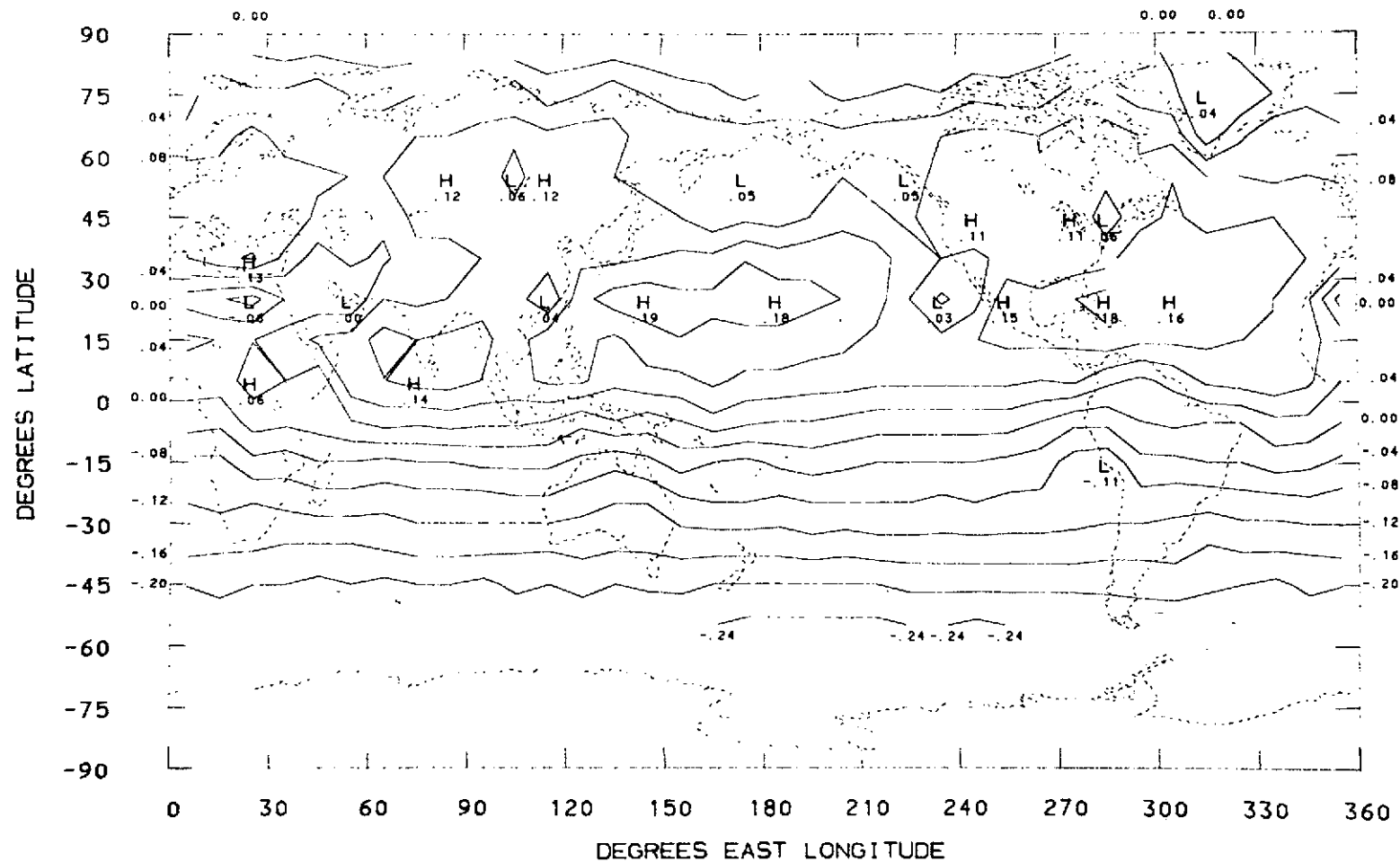
PLANETARY ALBEDO
JULY 1969



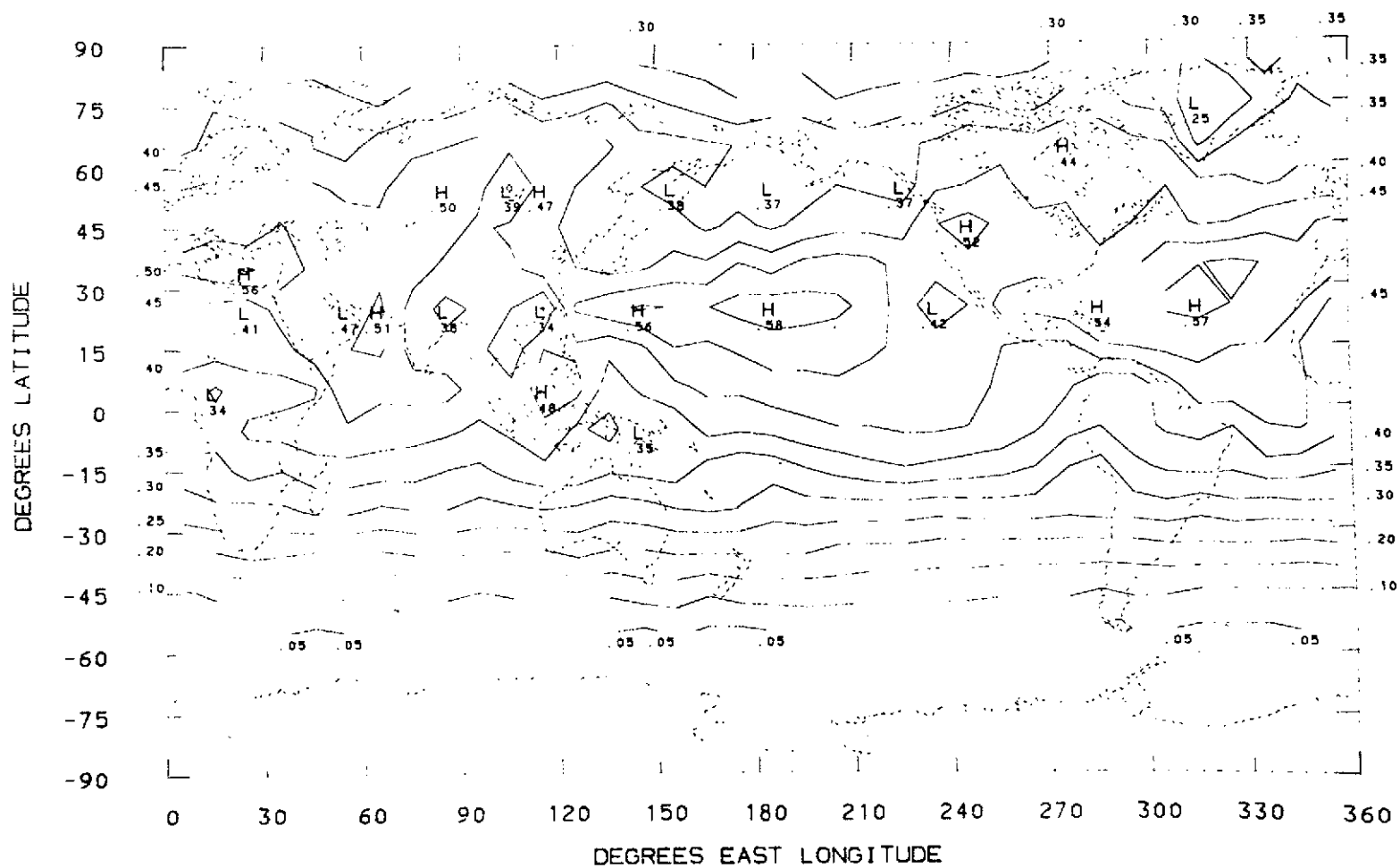
LONGWAVE RADIATION (LY/MIN)
JULY 1969



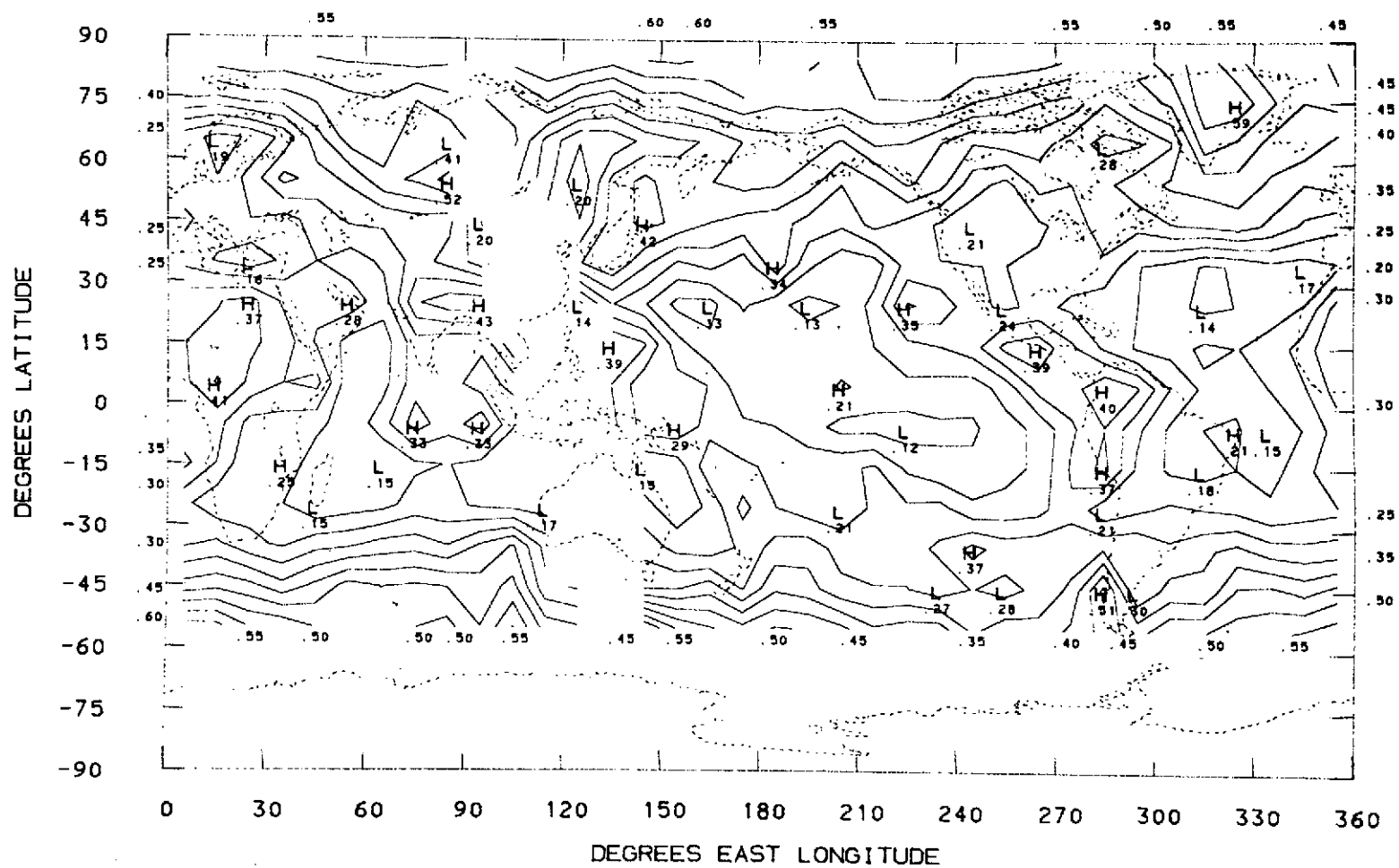
NET RADIATION (LY/MIN)
JULY 1969



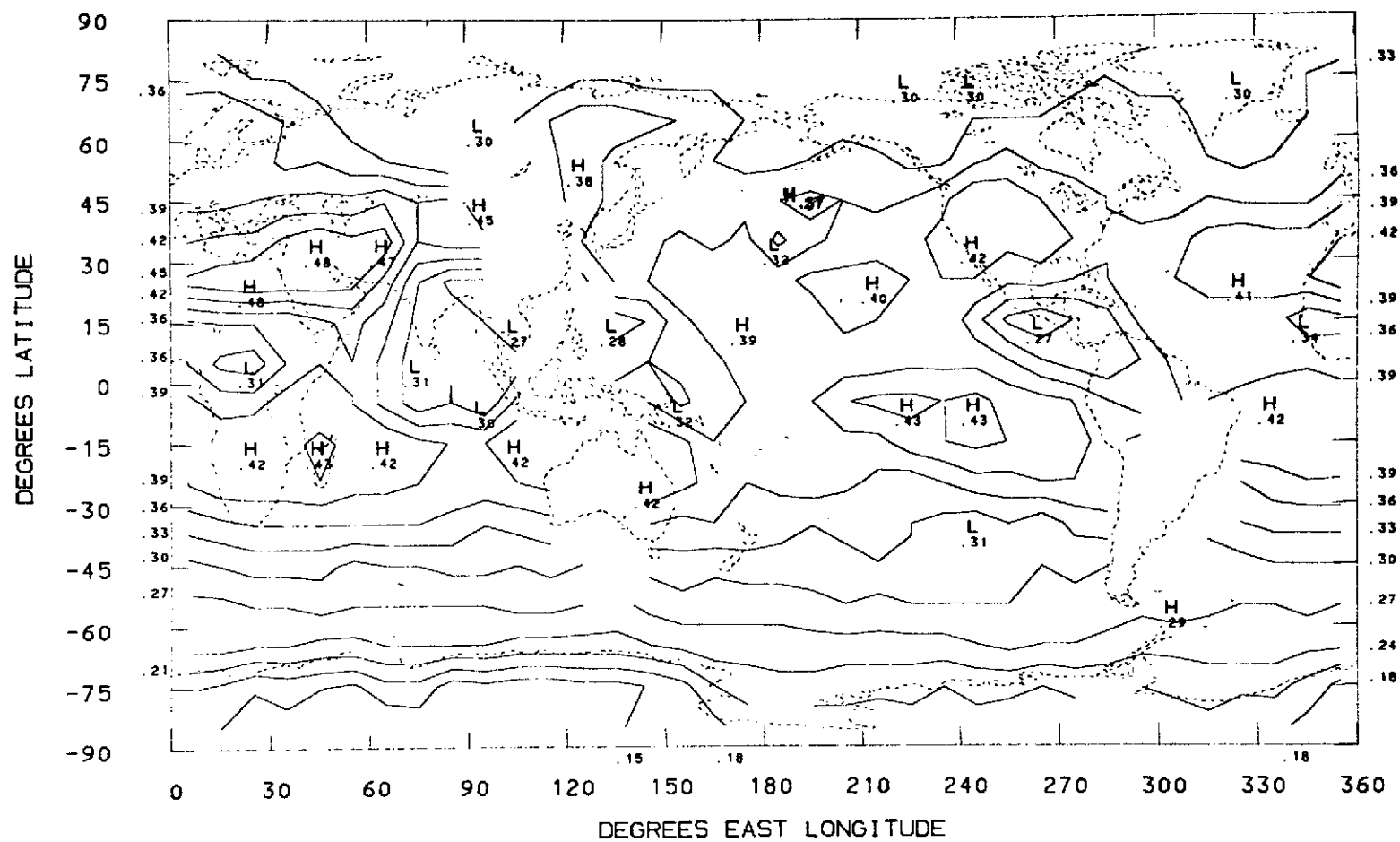
ABSORBED RADIATION (LY/MIN)
JULY 1969



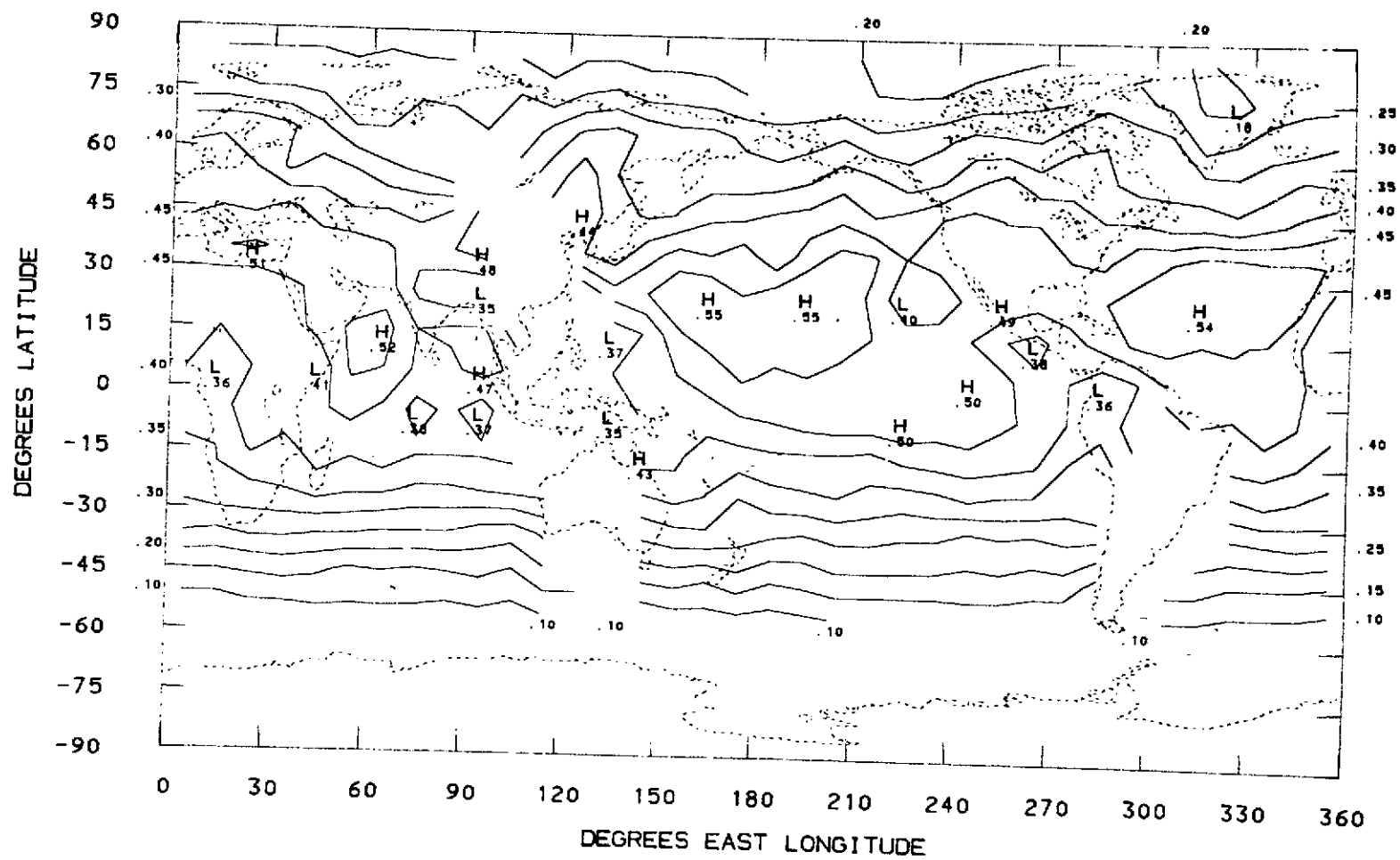
PLANETARY ALBEDO
AUGUST(1-15) 1969



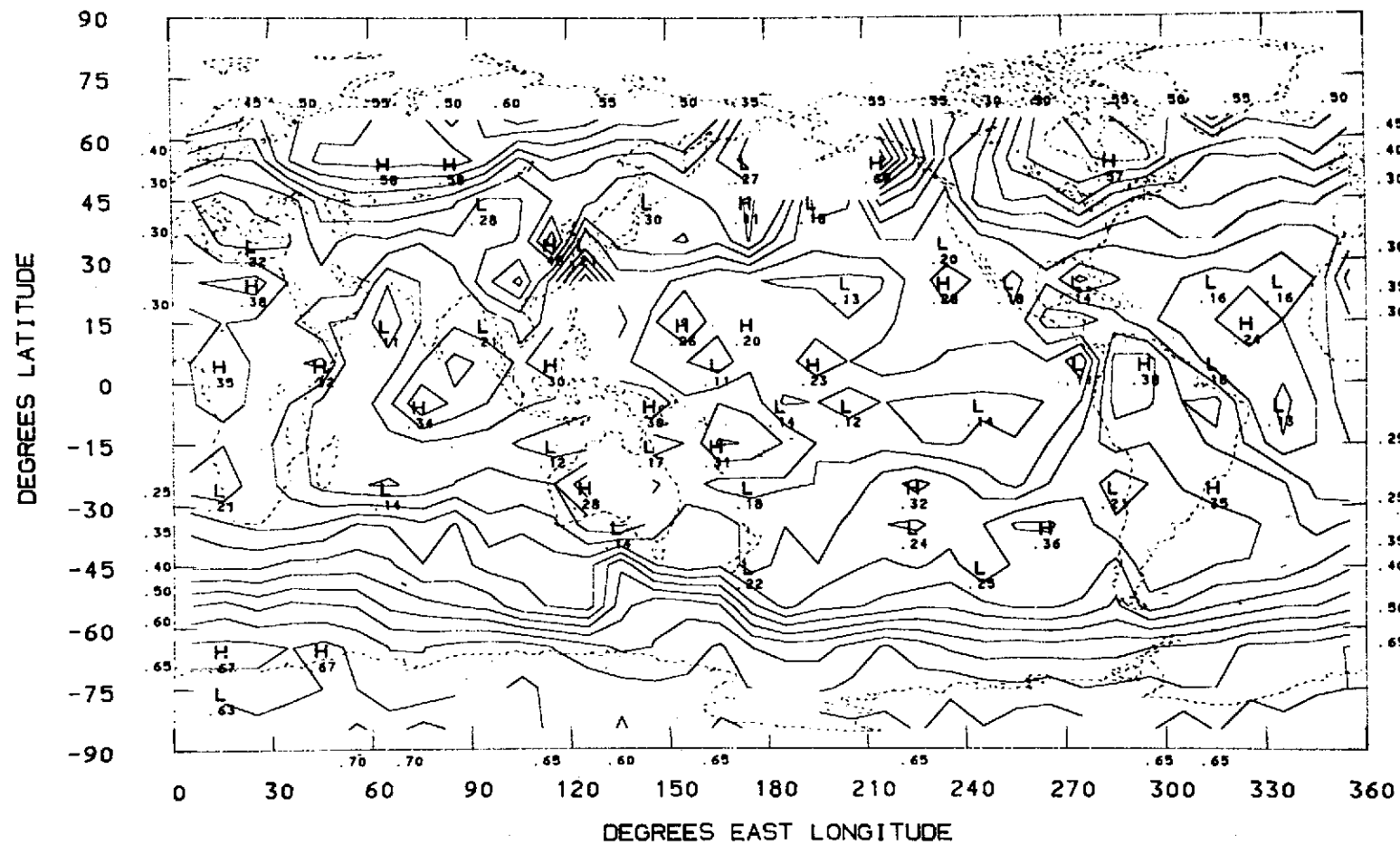
LONGWAVE RADIATION (LY/MIN)
AUGUST (1-15) 1969



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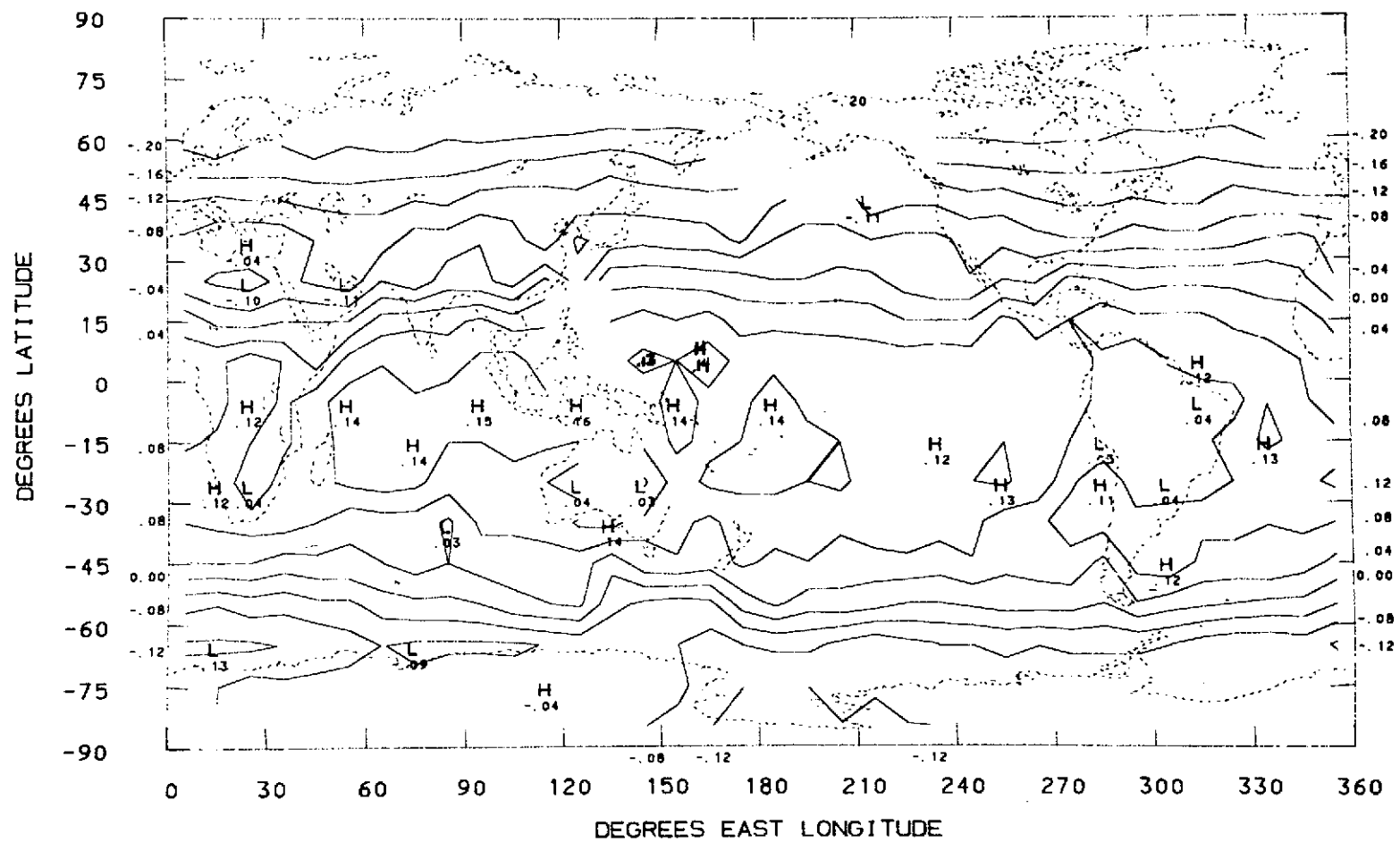
PLANETARY ALBEDO
OCTOBER(3-17) 1969



OCTOBER (3-17) 1969

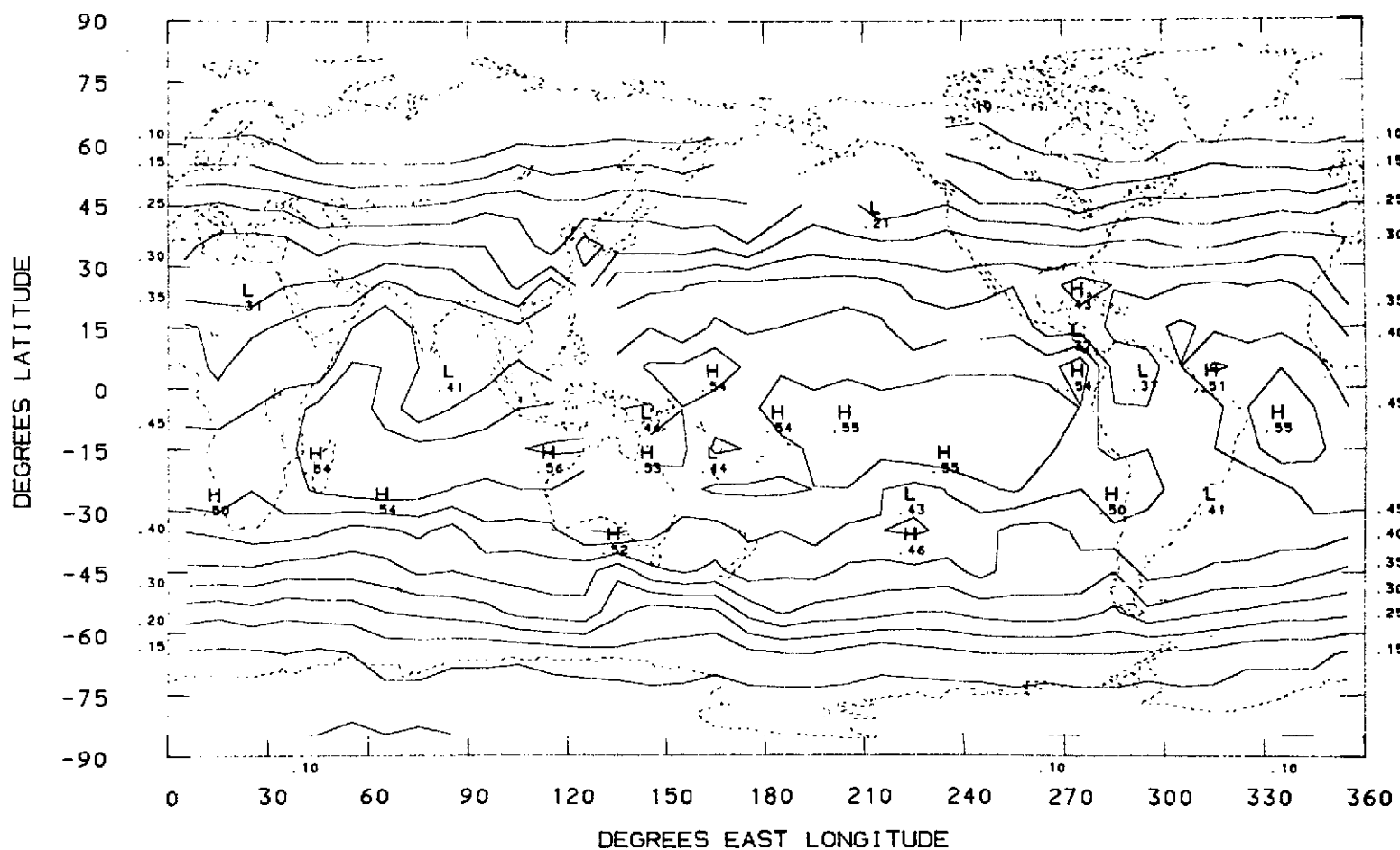


NET RADIATION (LY/MIN)
OCTOBER(3-17) 1969



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ABSORBED RADIATION (LY/MIN)
OCTOBER (3-17) 1969



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PLANETARY ALBEDO
JAN(21) FEB(3) 1970

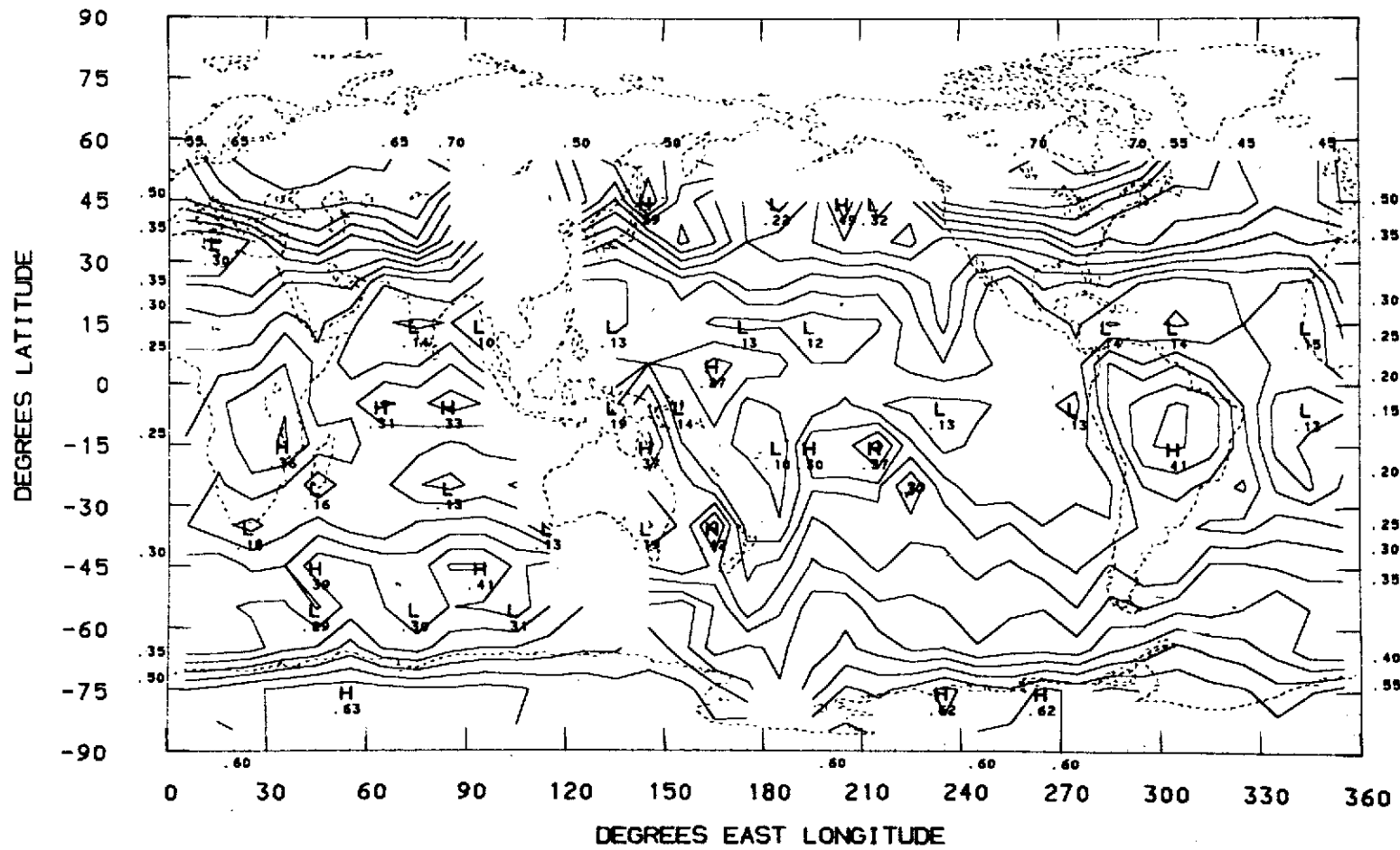
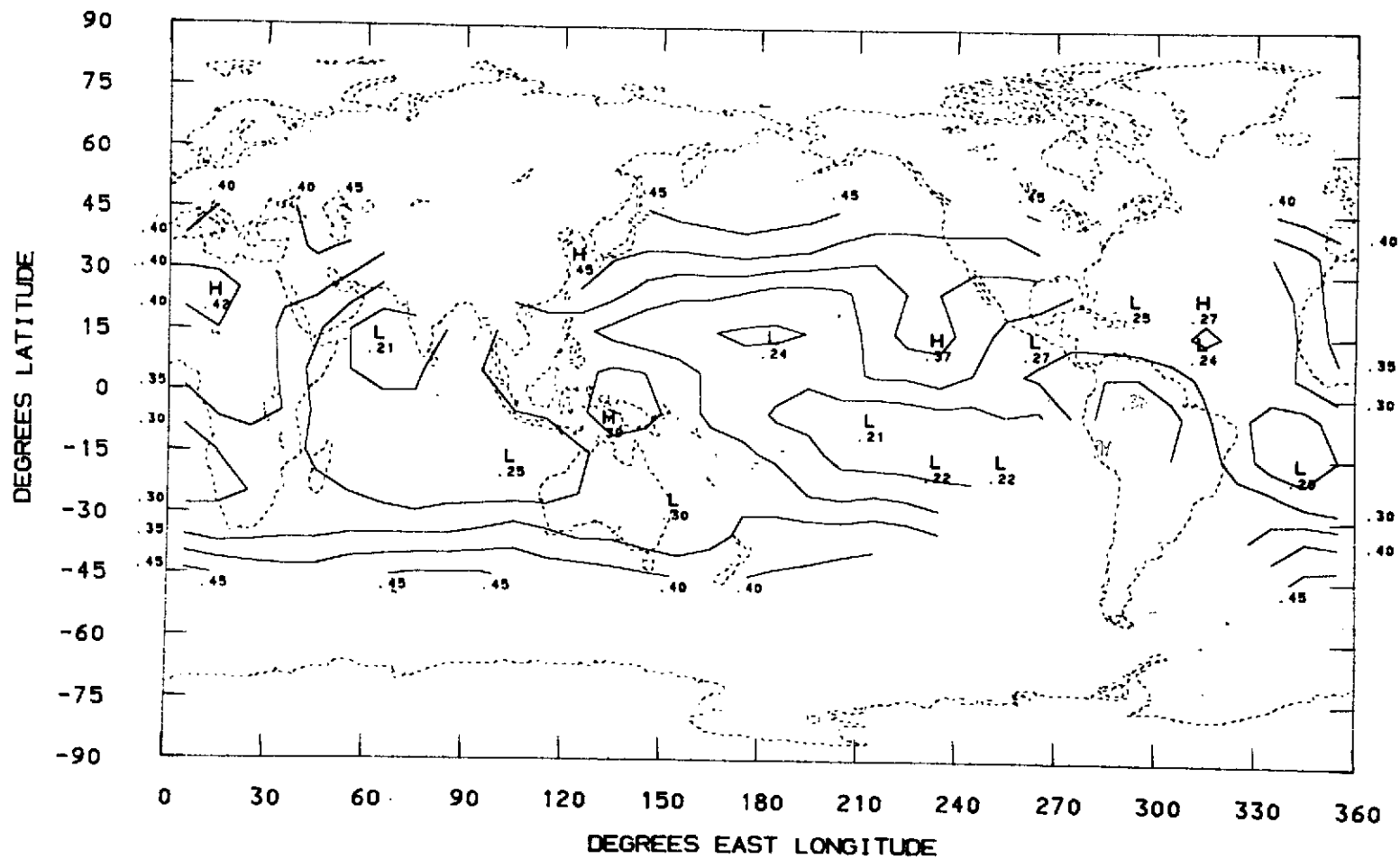


Figure 1 is a map of the North Pacific region, showing sea level pressure (SLP) contours and wind vectors. The map covers a latitude range from 90°N to 90°S and a longitude range from 0° to 360°. The SLP contours are represented by solid lines, and the wind vectors are shown as dashed lines. High pressure (H) and low pressure (L) systems are labeled with their respective SLP values. The map illustrates the spatial distribution of SLP and wind patterns in the North Pacific, with a focus on the area around 45°N, 180°E.

JAN(21)-FEB(3) 1970

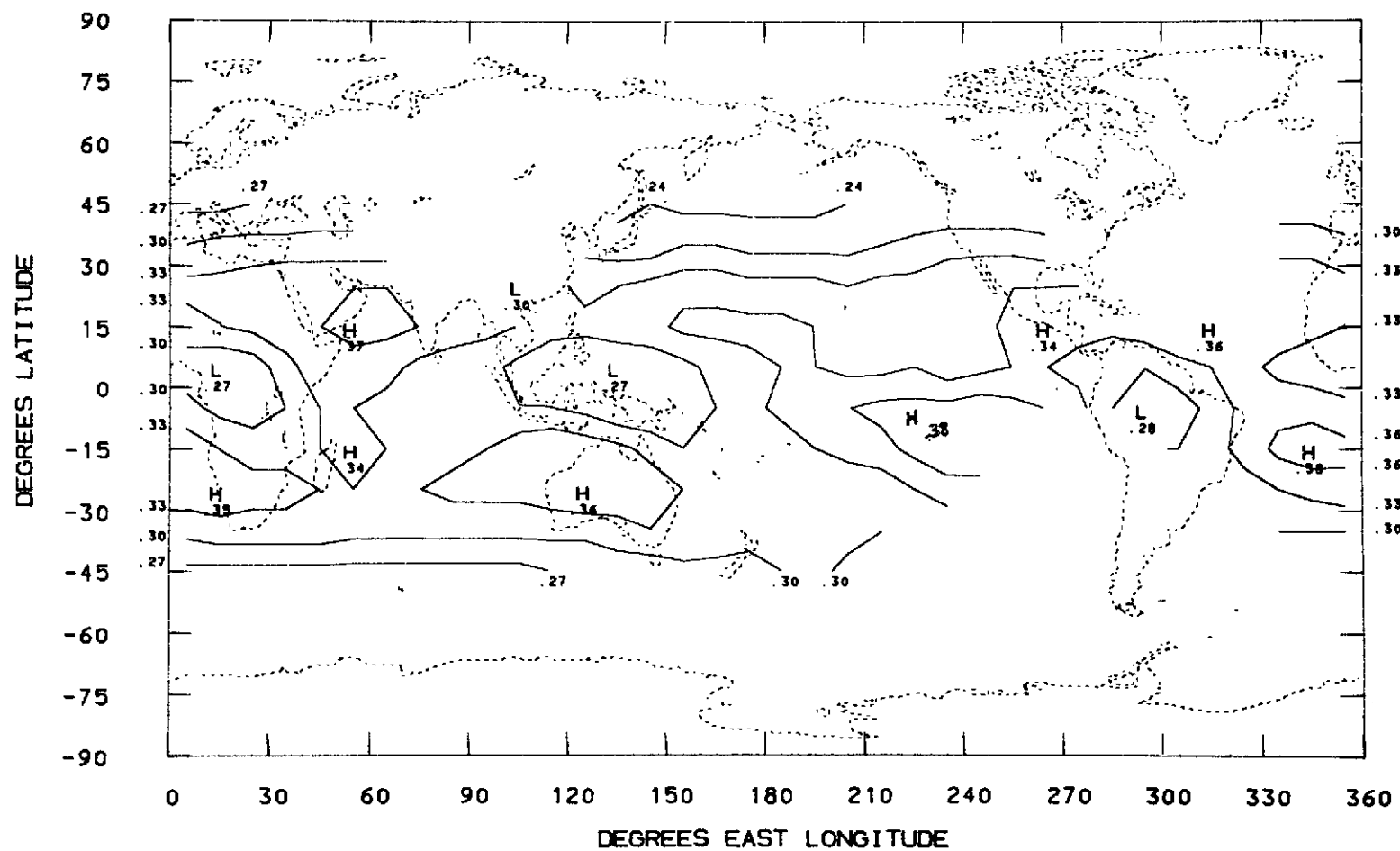


PLANETARY ALBEDO
MAR APR MAY 1962

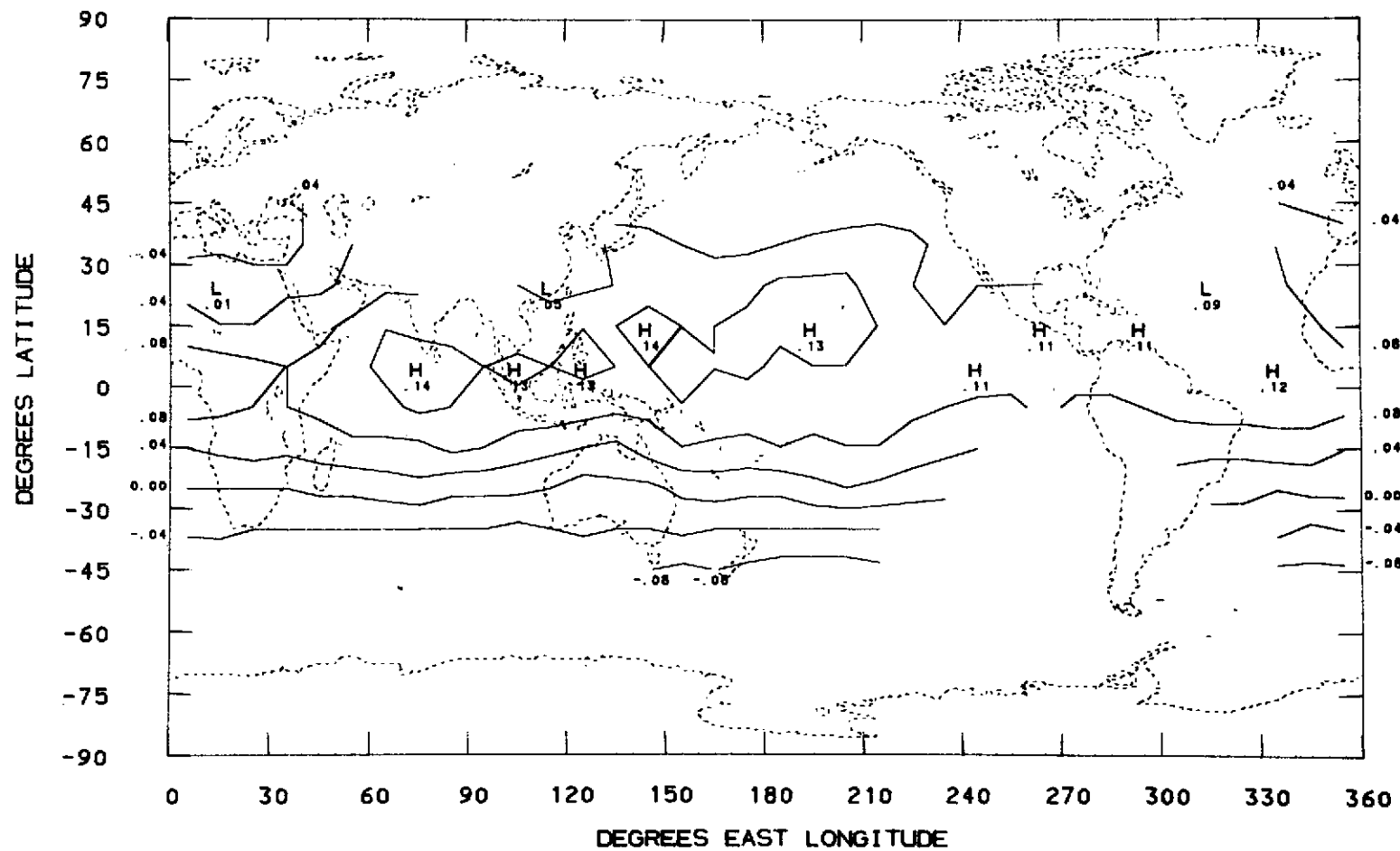


LONGWAVE RADIATION (LY/MIN)

MAR APR MAY 1962

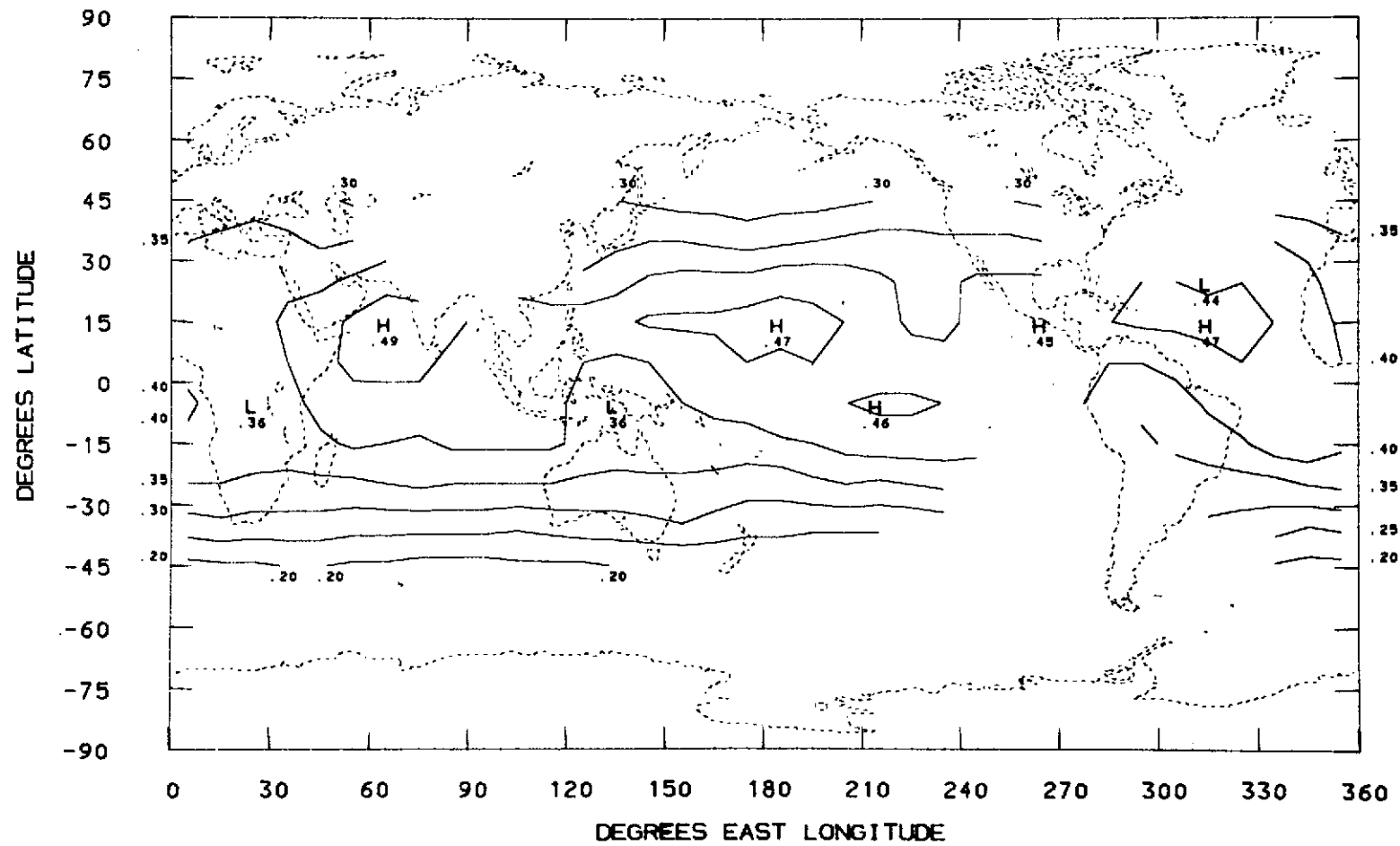


NET RADIATION (LY/MIN)
MAR APR MAY 1962

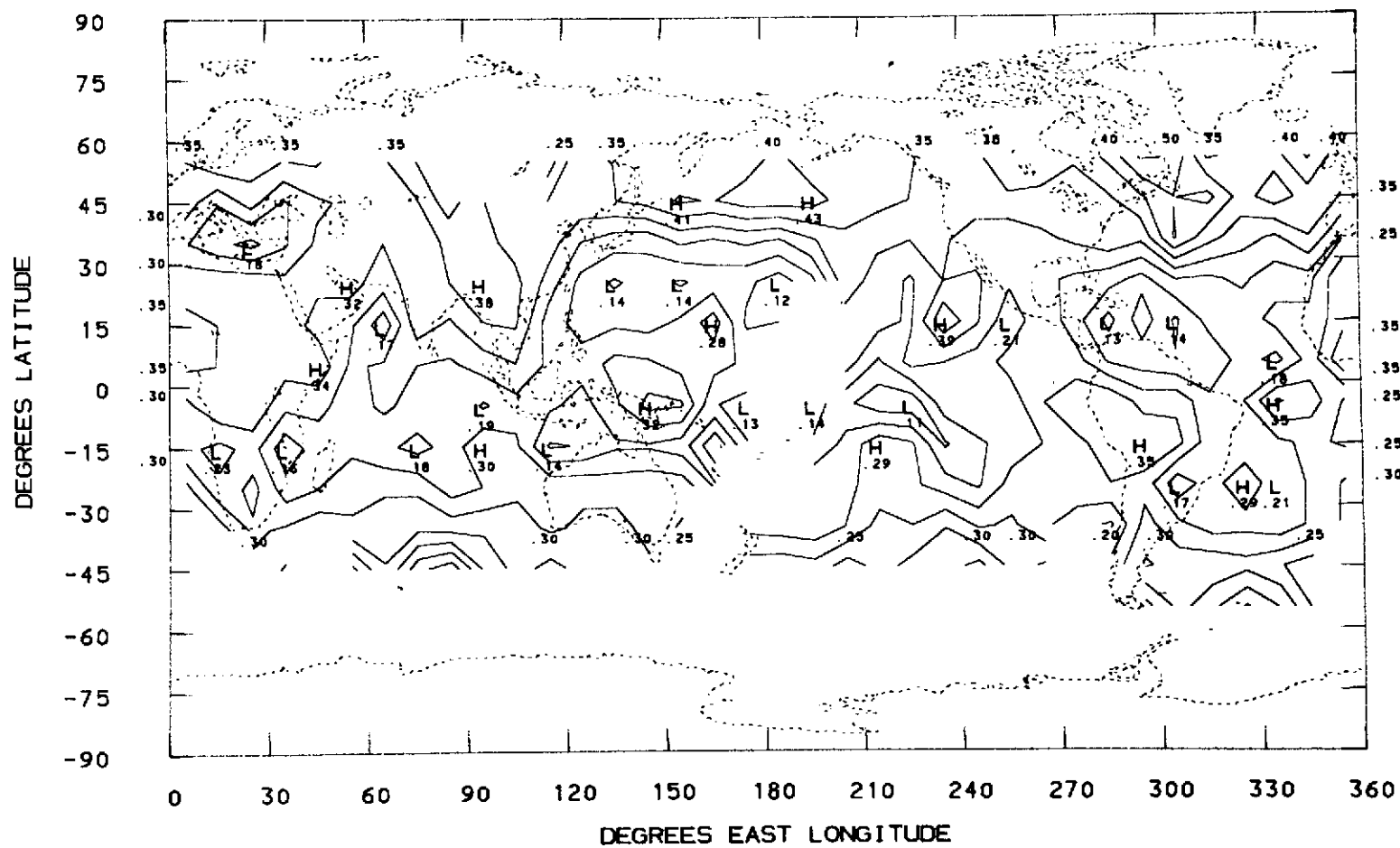


ABSORBED RADIATION (LY/MIN)

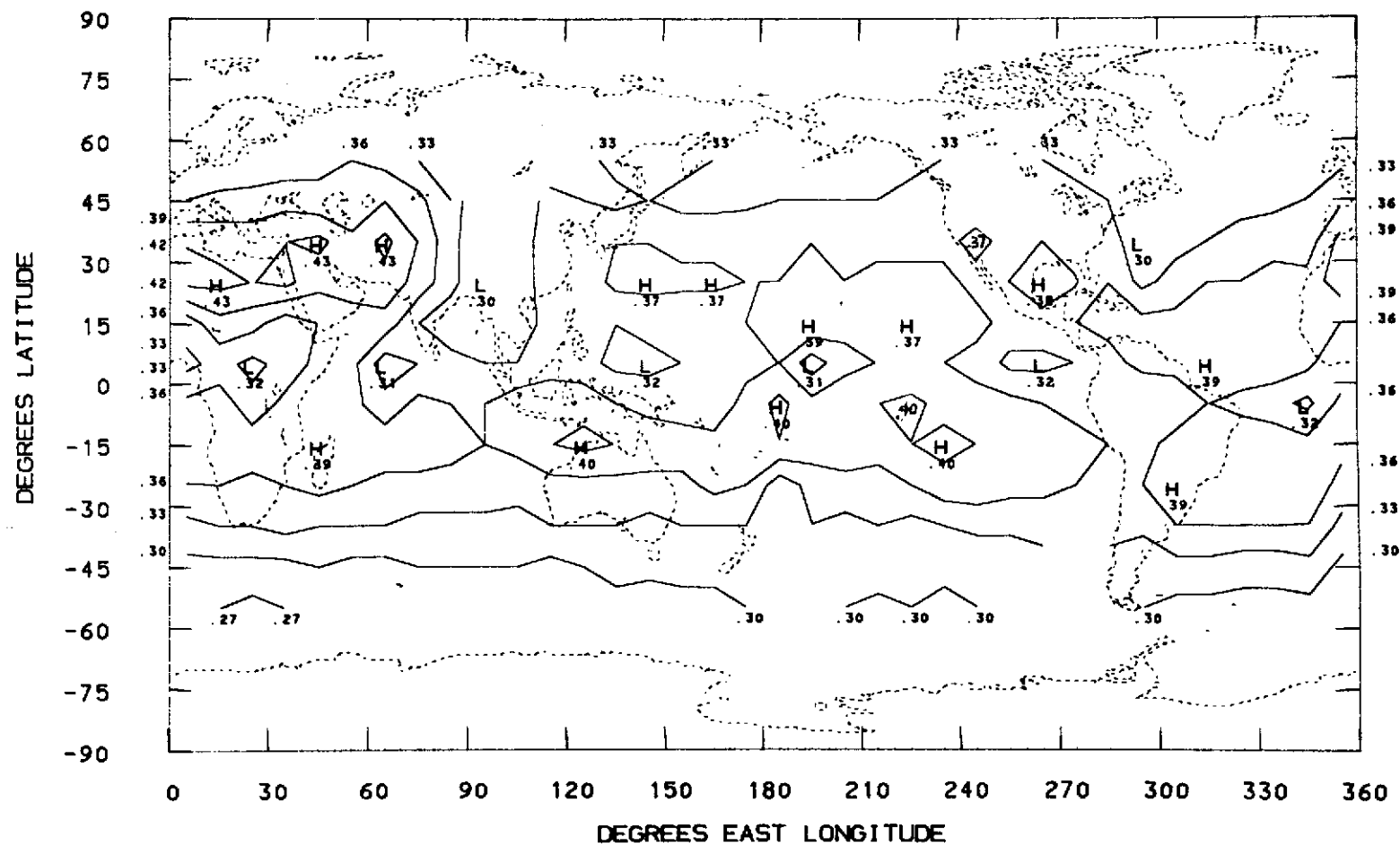
MAR APR MAY 1962



PLANETARY ALBEDO
JUN JUL AUG 1963

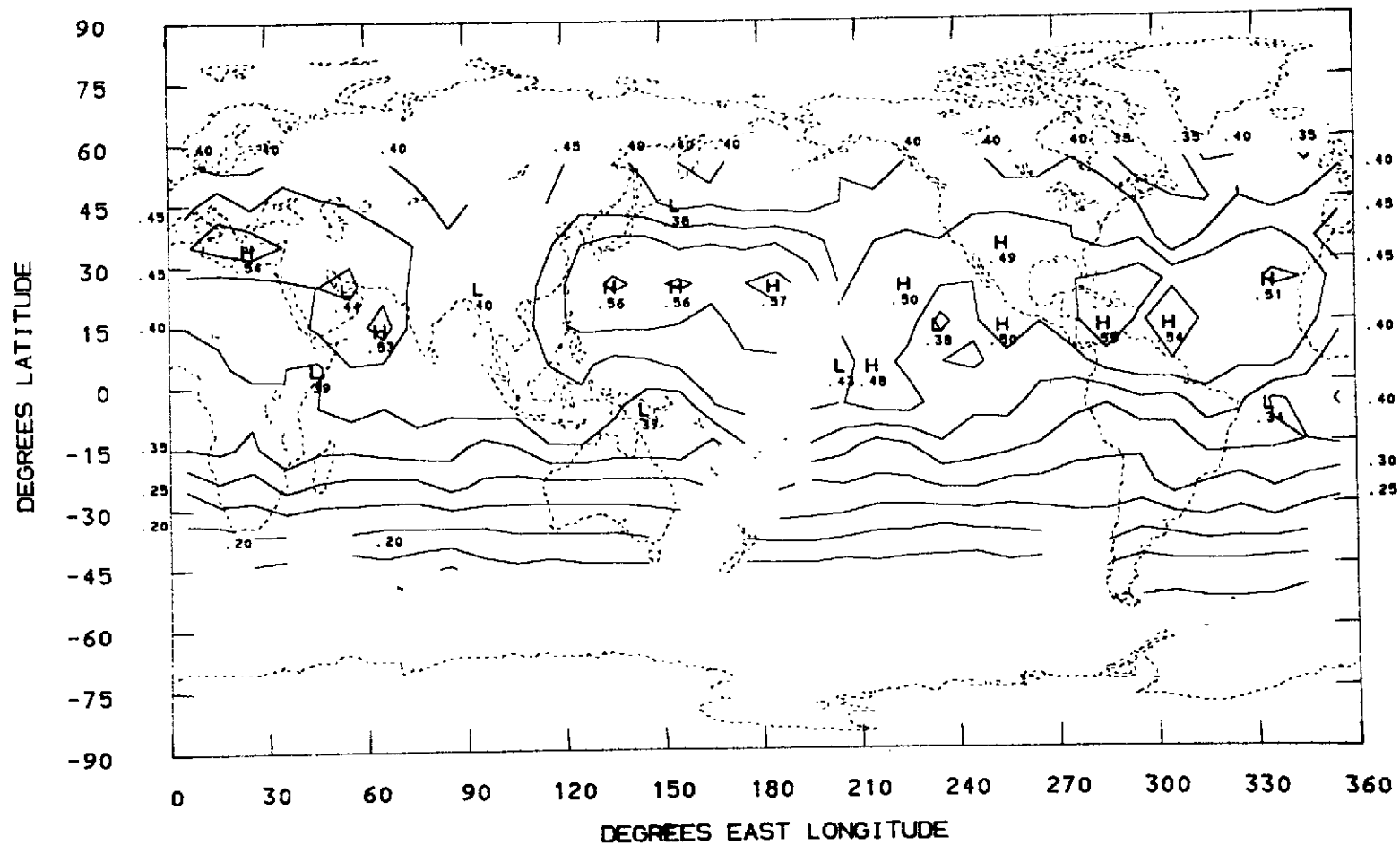


LONGWAVE RADIATION (LY/MIN)
JUN JUL AUG 1963

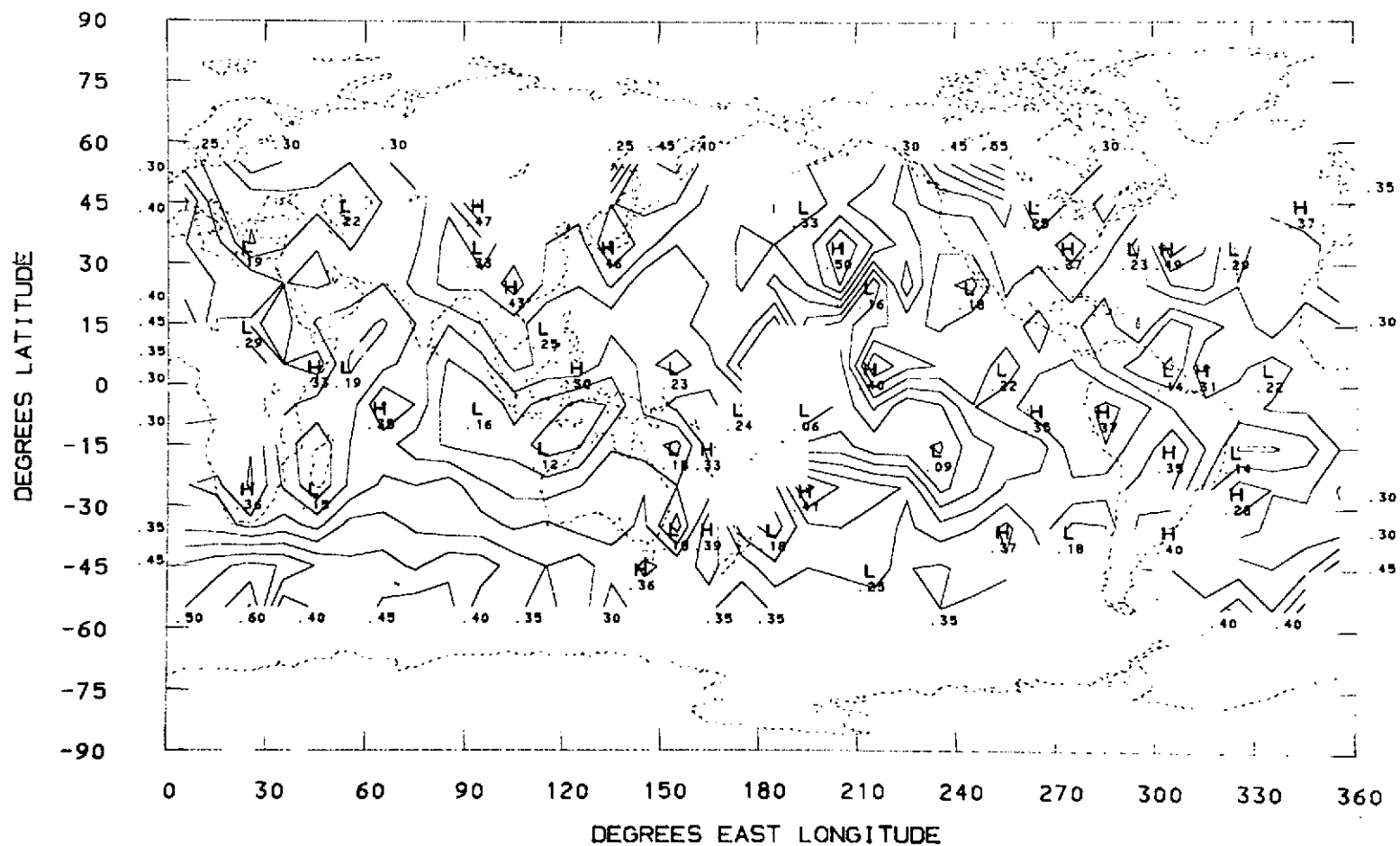


ABSORBED RADIATION (LY/MIN)

JUN JUL AUG 1963

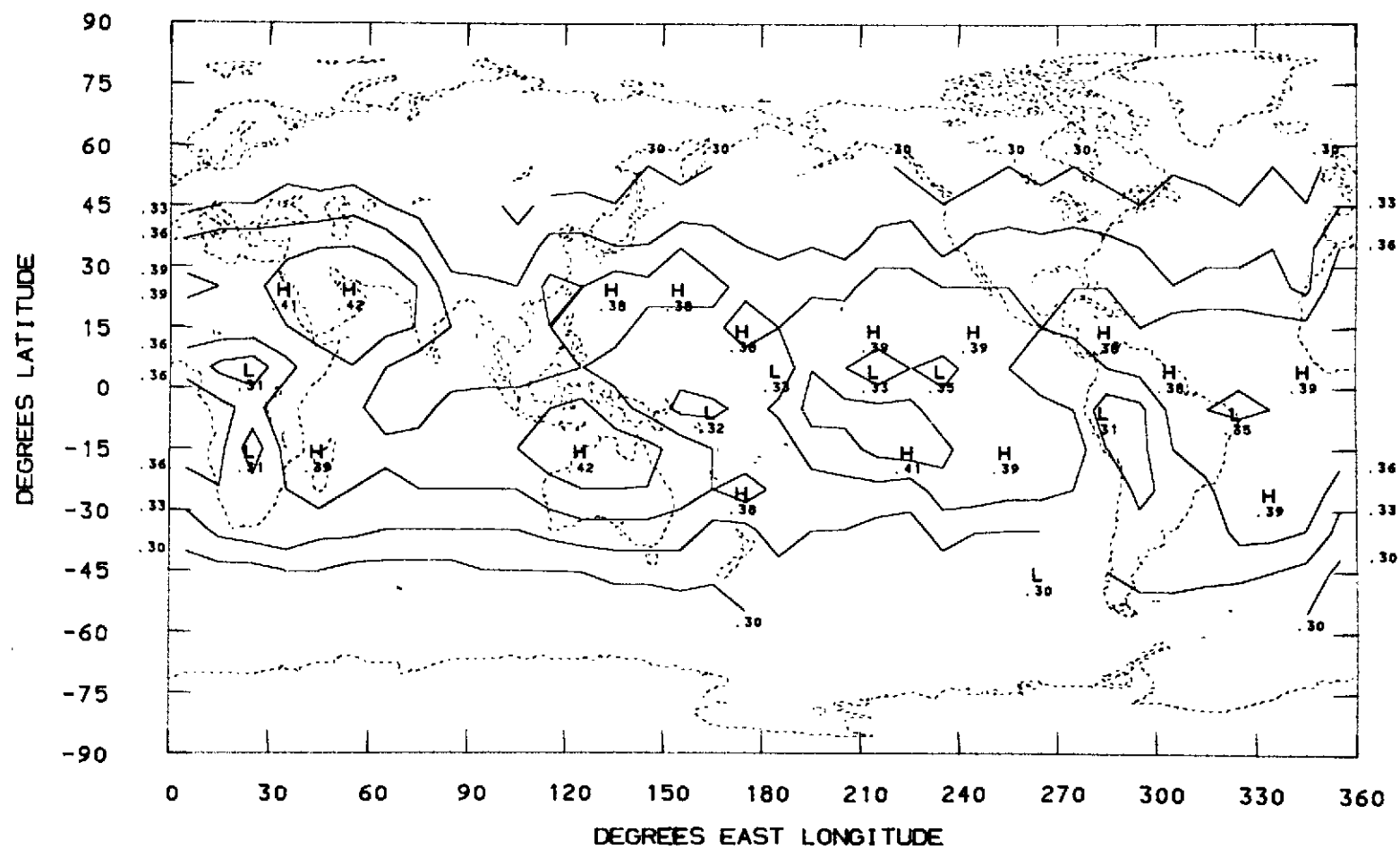


PLANETARY ALBEDO
SEP OCT NOV 1963

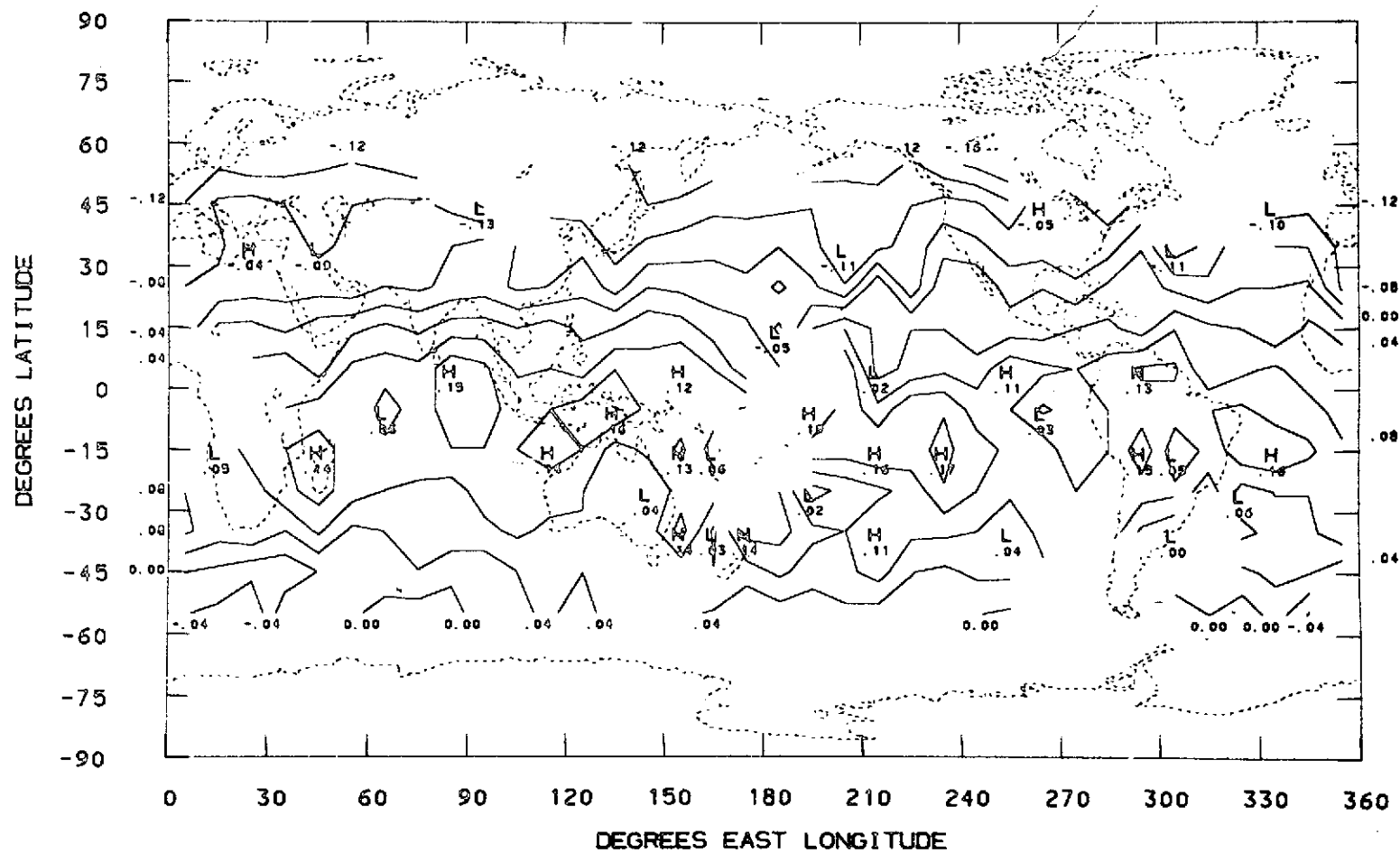


LONGWAVE RADIATION (LY/MIN)

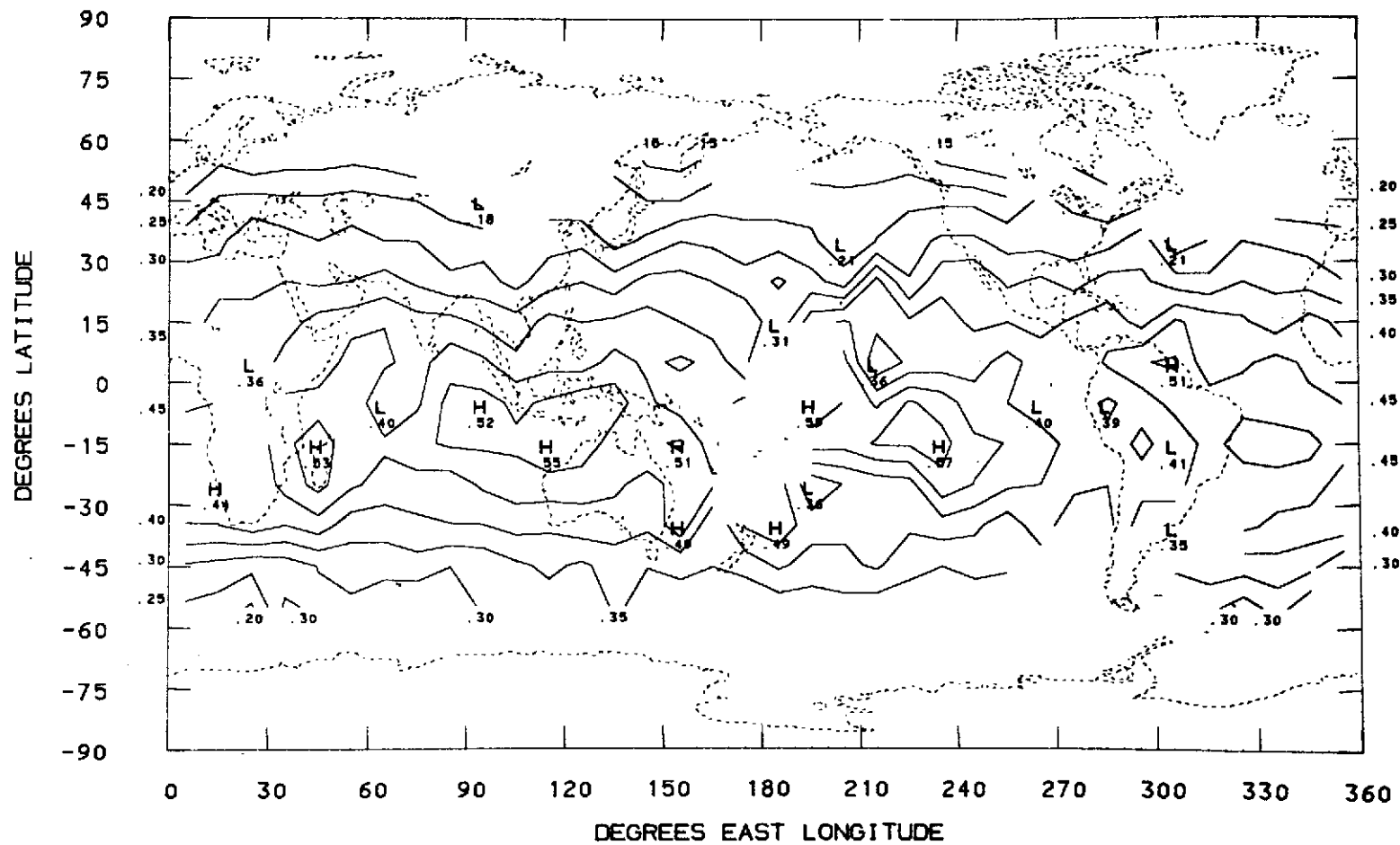
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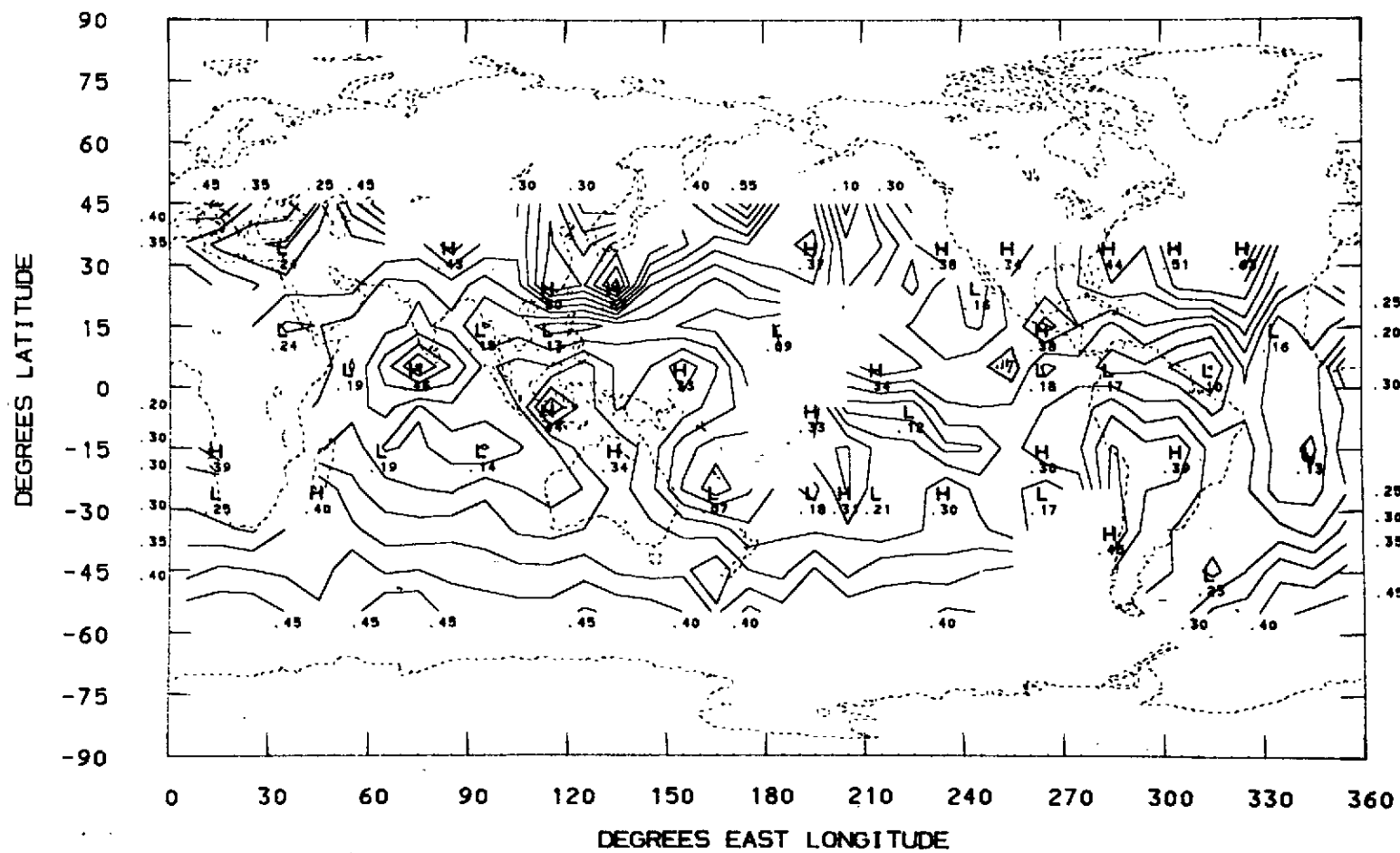
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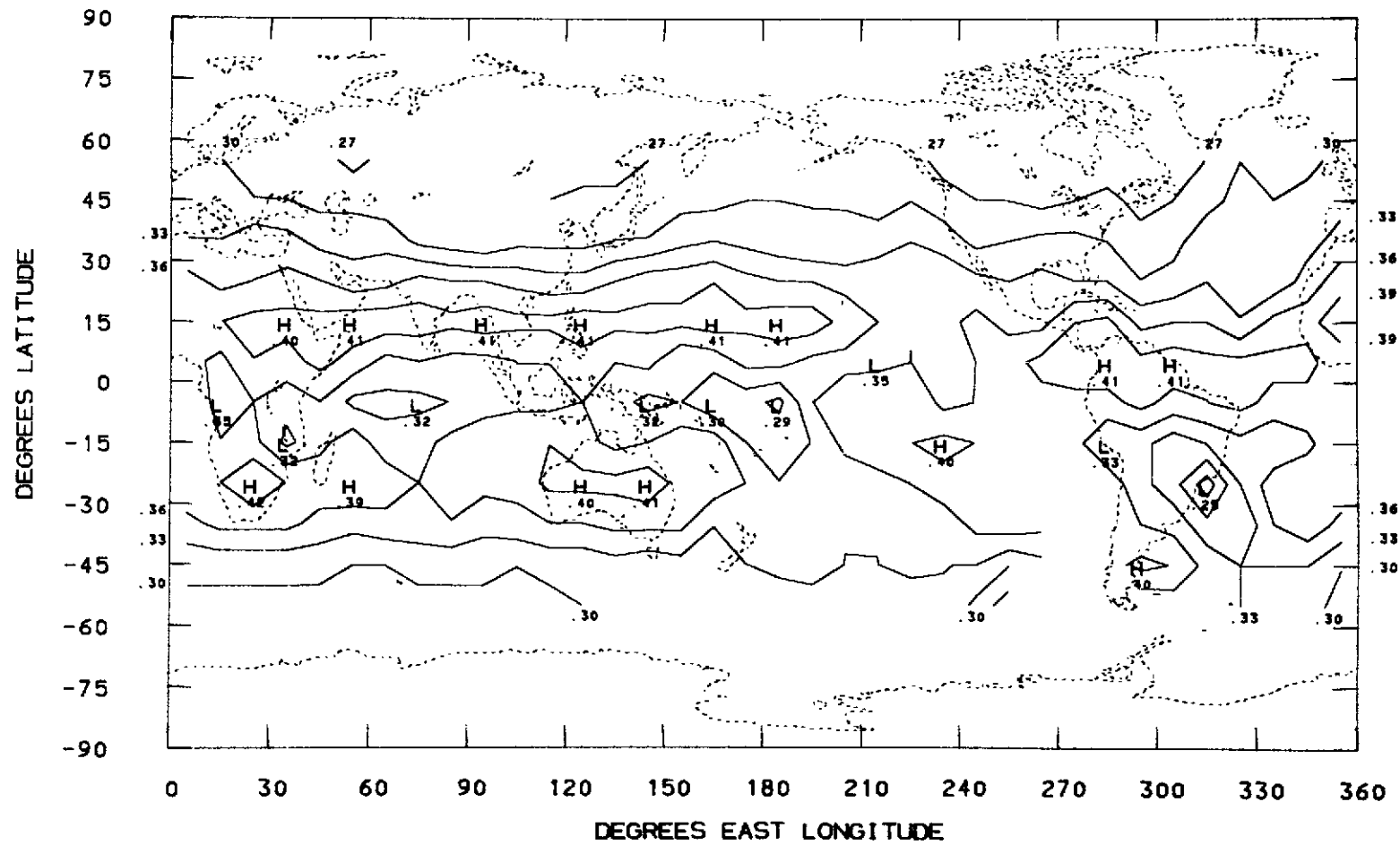
ABSORBED RADIATION (LY/MIN)
SEP OCT NOV 1963



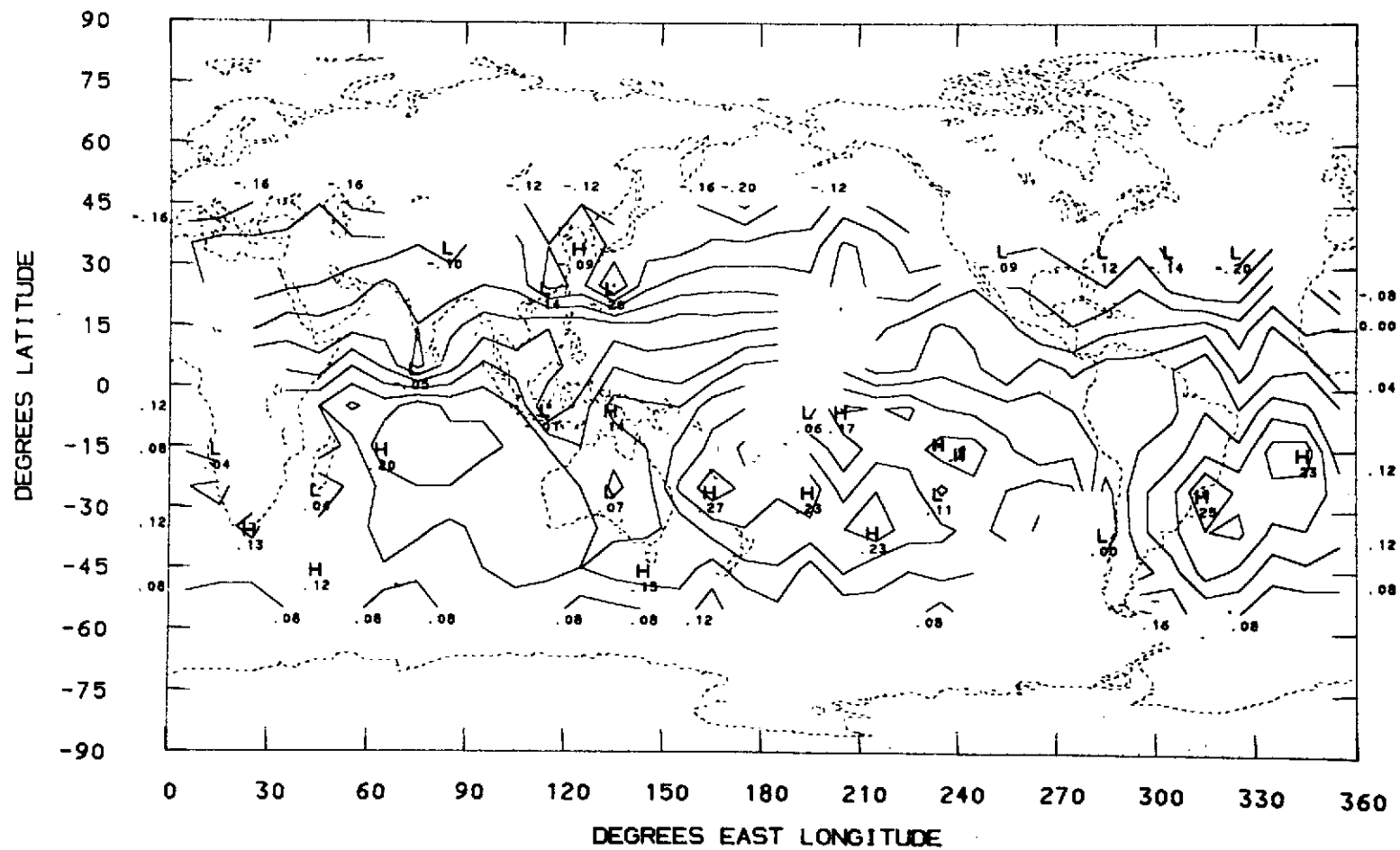
PLANETARY ALBEDO
DEC JAN FEB 1963/1964



LONGWAVE RADIATION (LY/MIN)
DEC JAN FEB 1963/1964

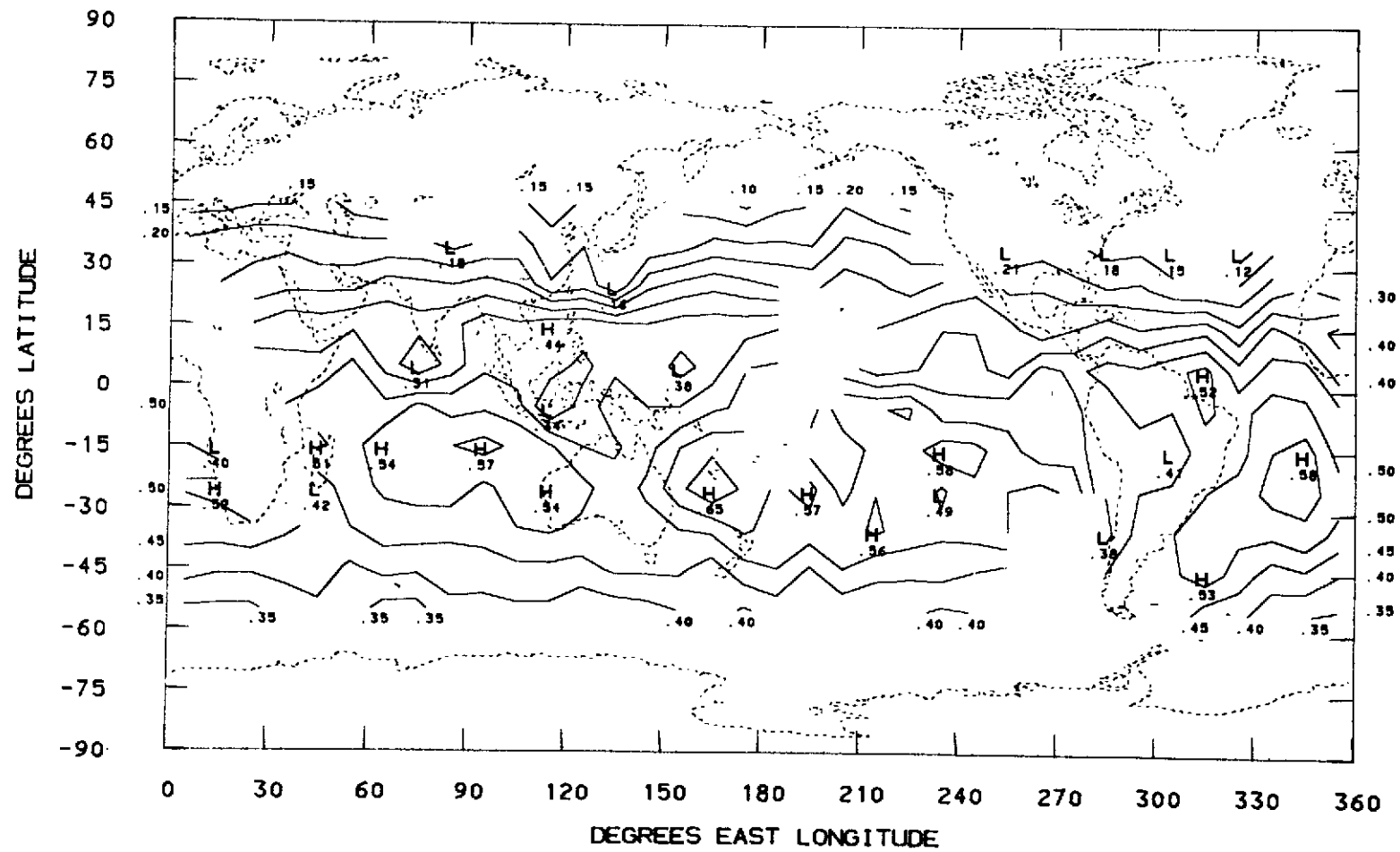


NET RADIATION (LY/MIN)
DEC JAN FEB 1963/1964

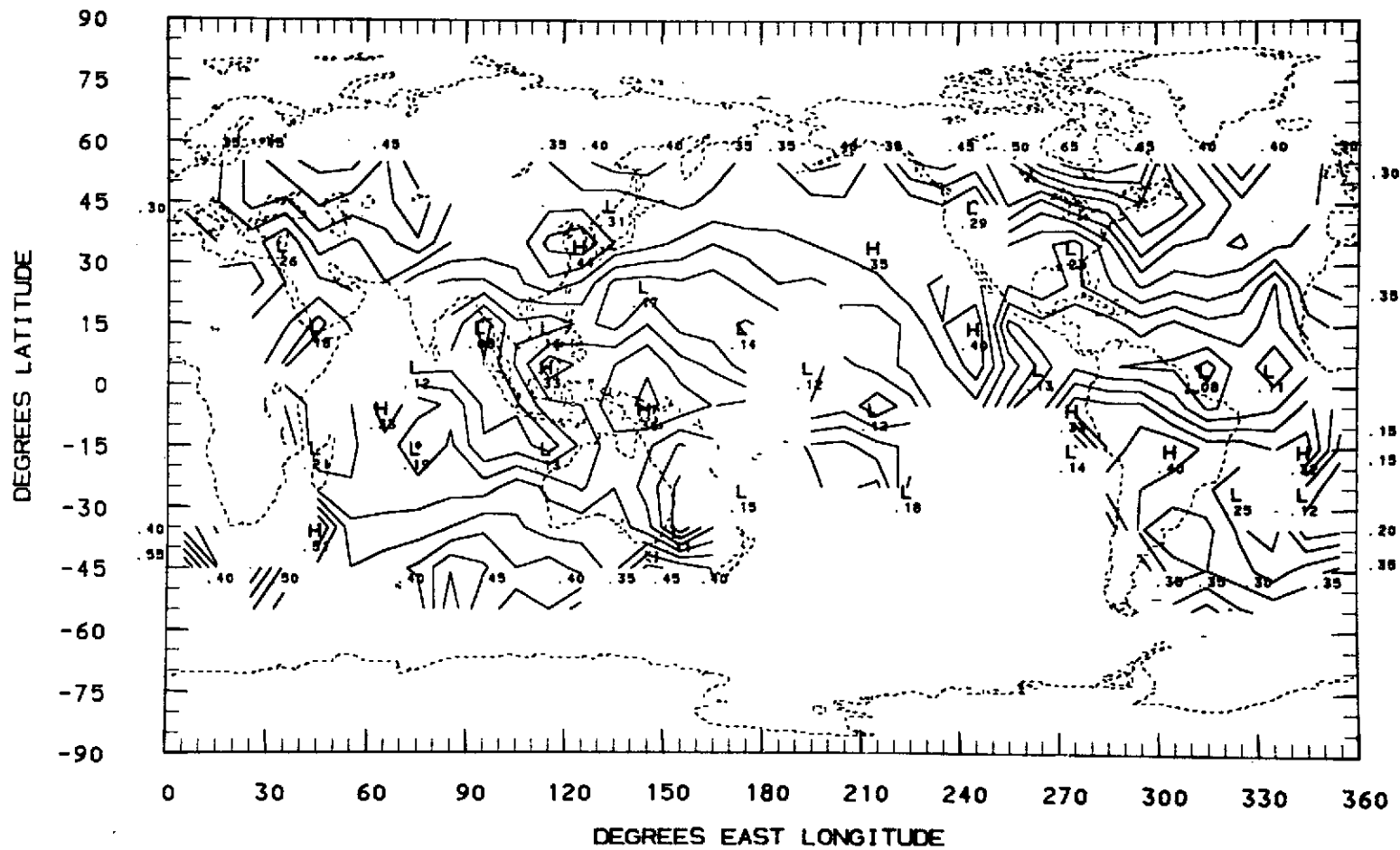


ABSORBED RADIATION (LY/MIN)

DEC JAN FEB 1963/1964

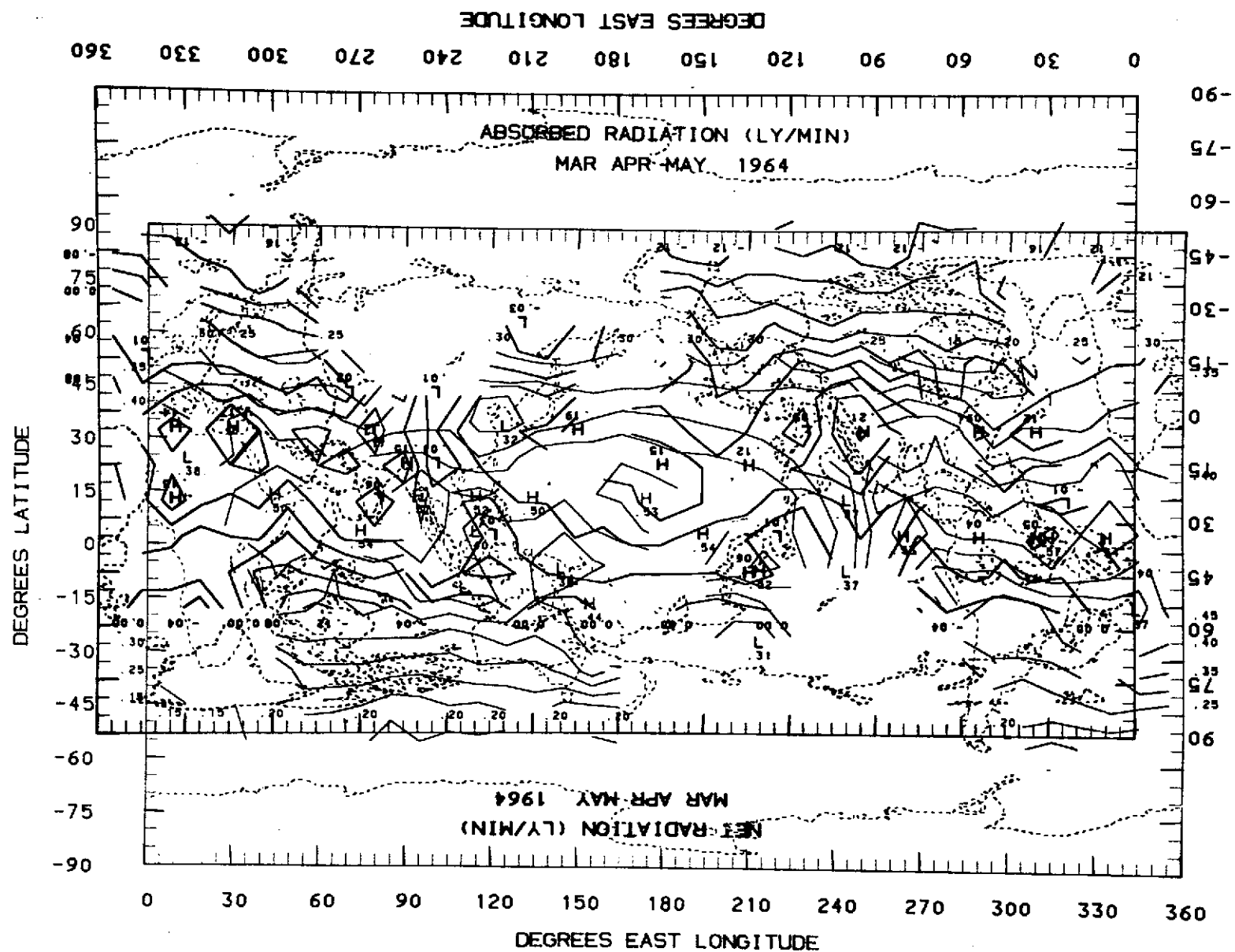


PLANETARY ALBEDO
MAR APR MAY 1964

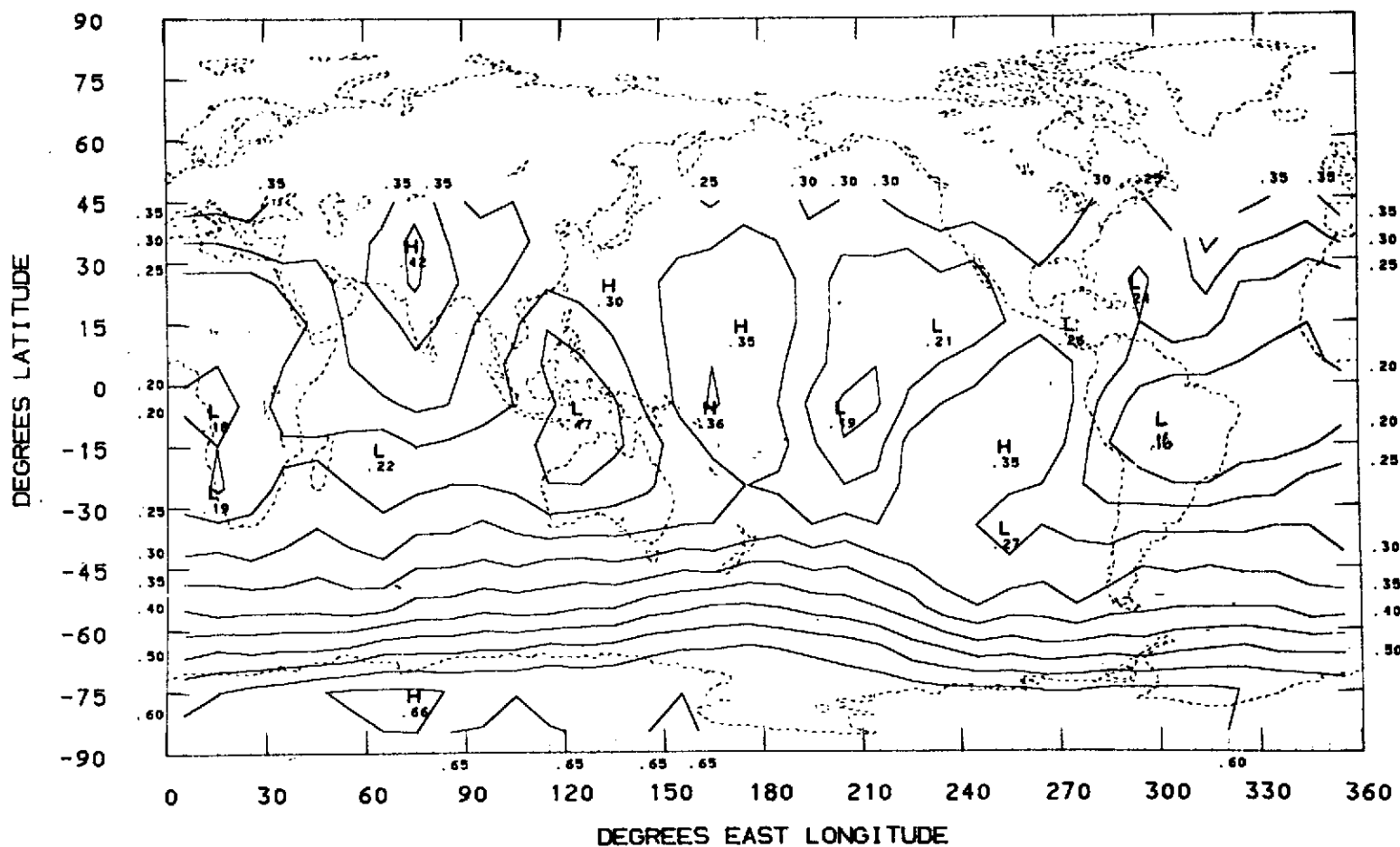


MAR APR MAY 1964

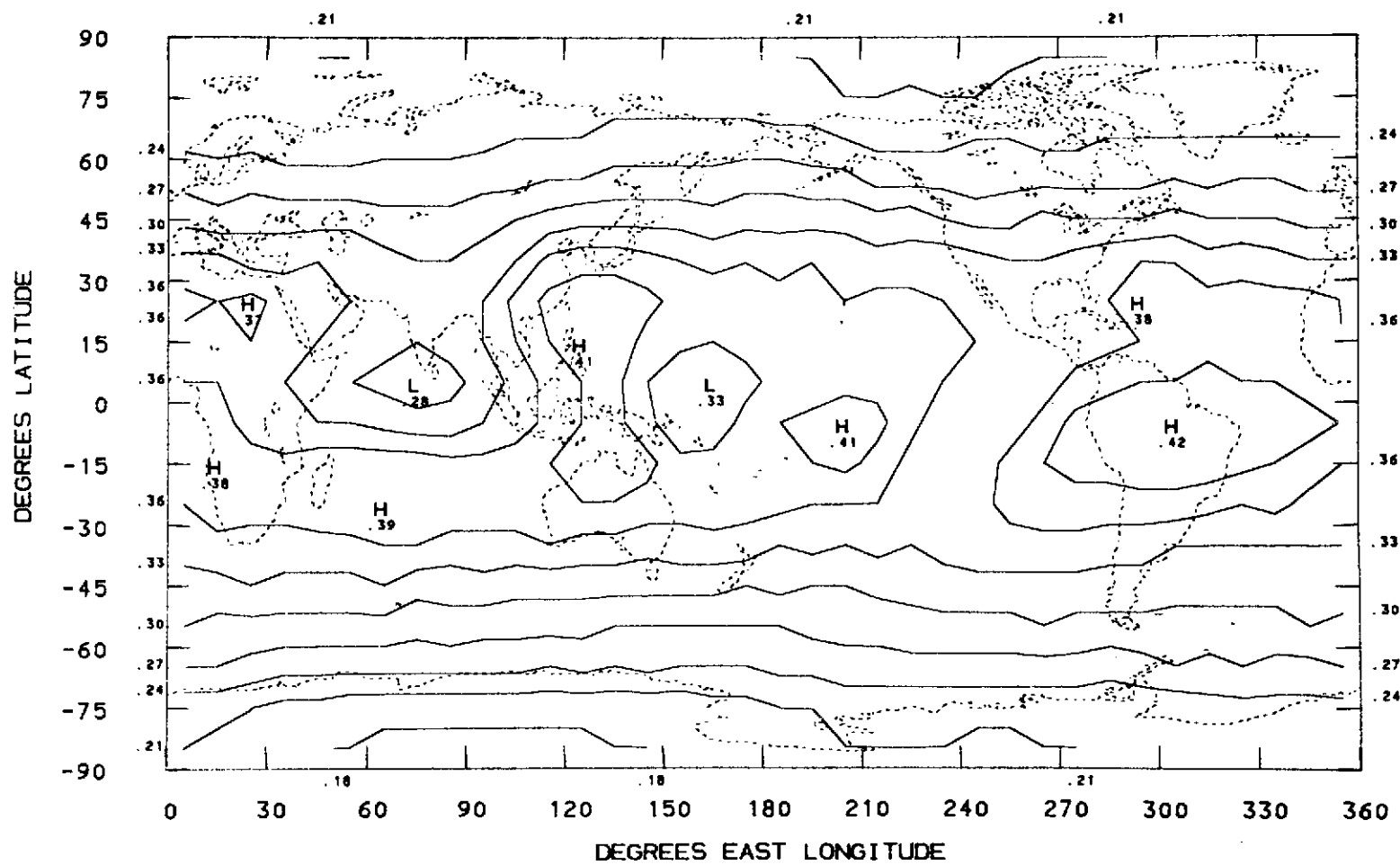




PLANETARY ALBEDO
SEP OCT NOV 1964



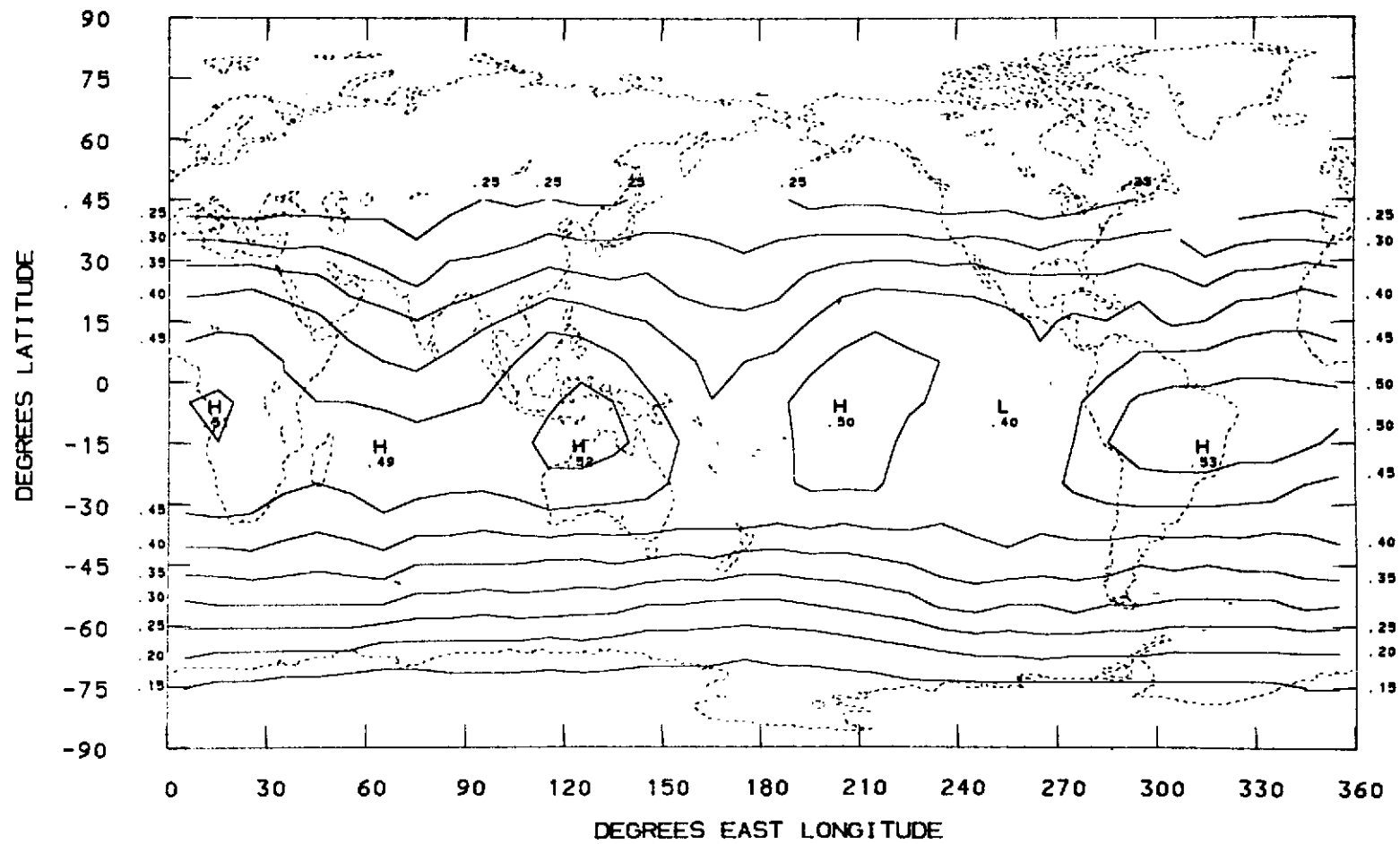
LONGWAVE RADIATION (LY/MIN)
SEP OCT NOV 1964



SEP OCT NOV 1964



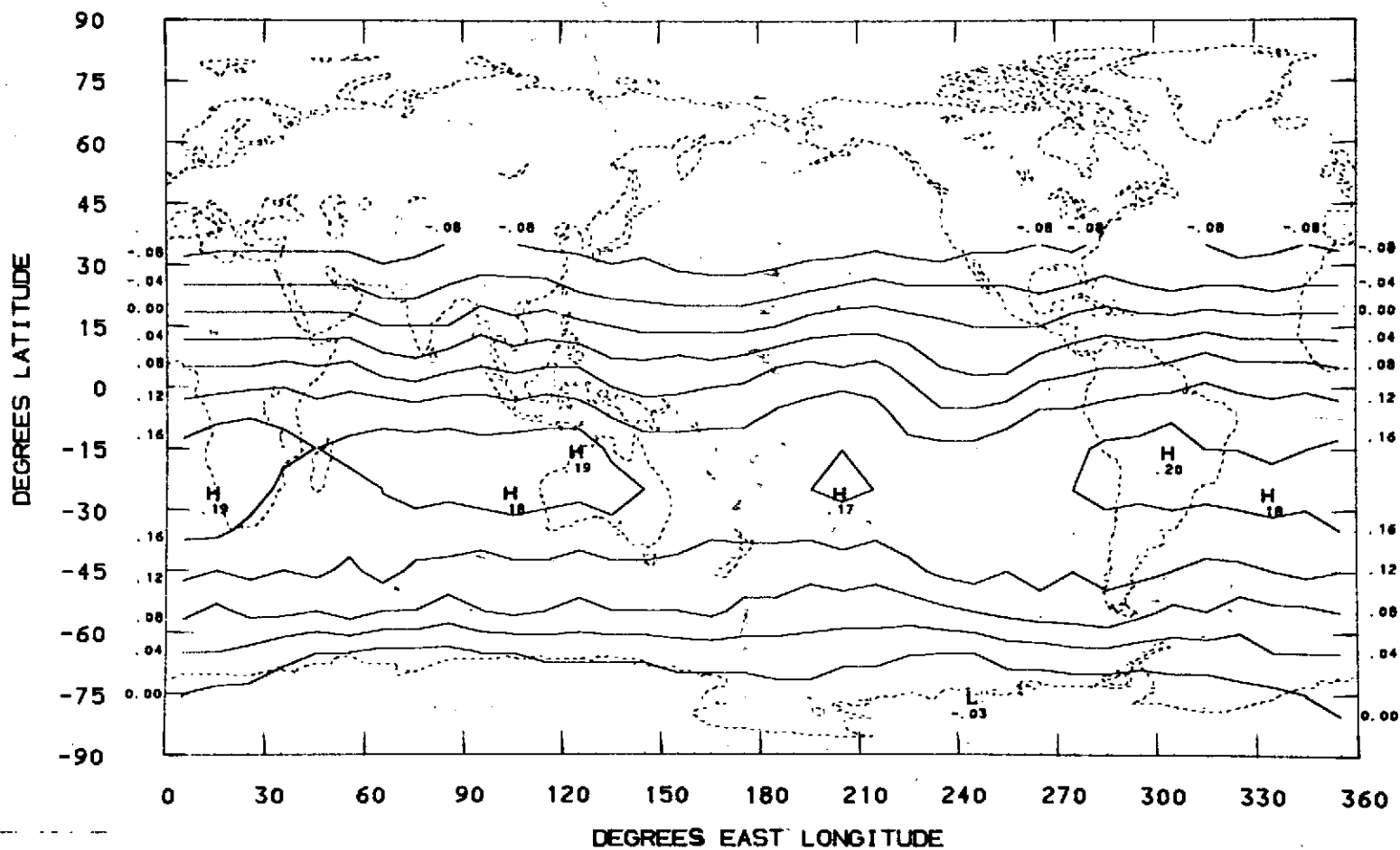
ABSORBED RADIATION (LY/MIN)
SEP OCT NOV 1964



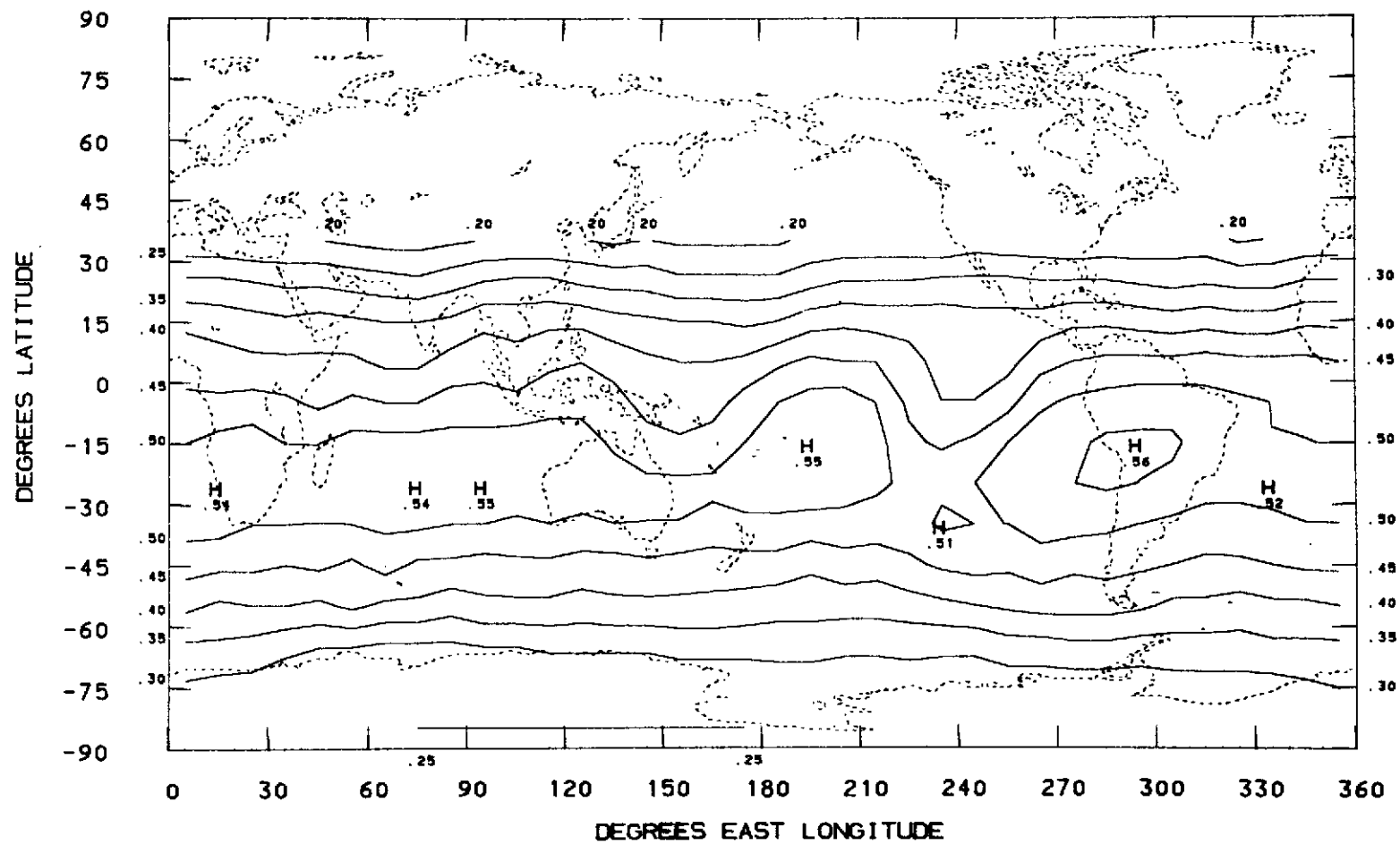
DEC JAN FEB 1964/1965



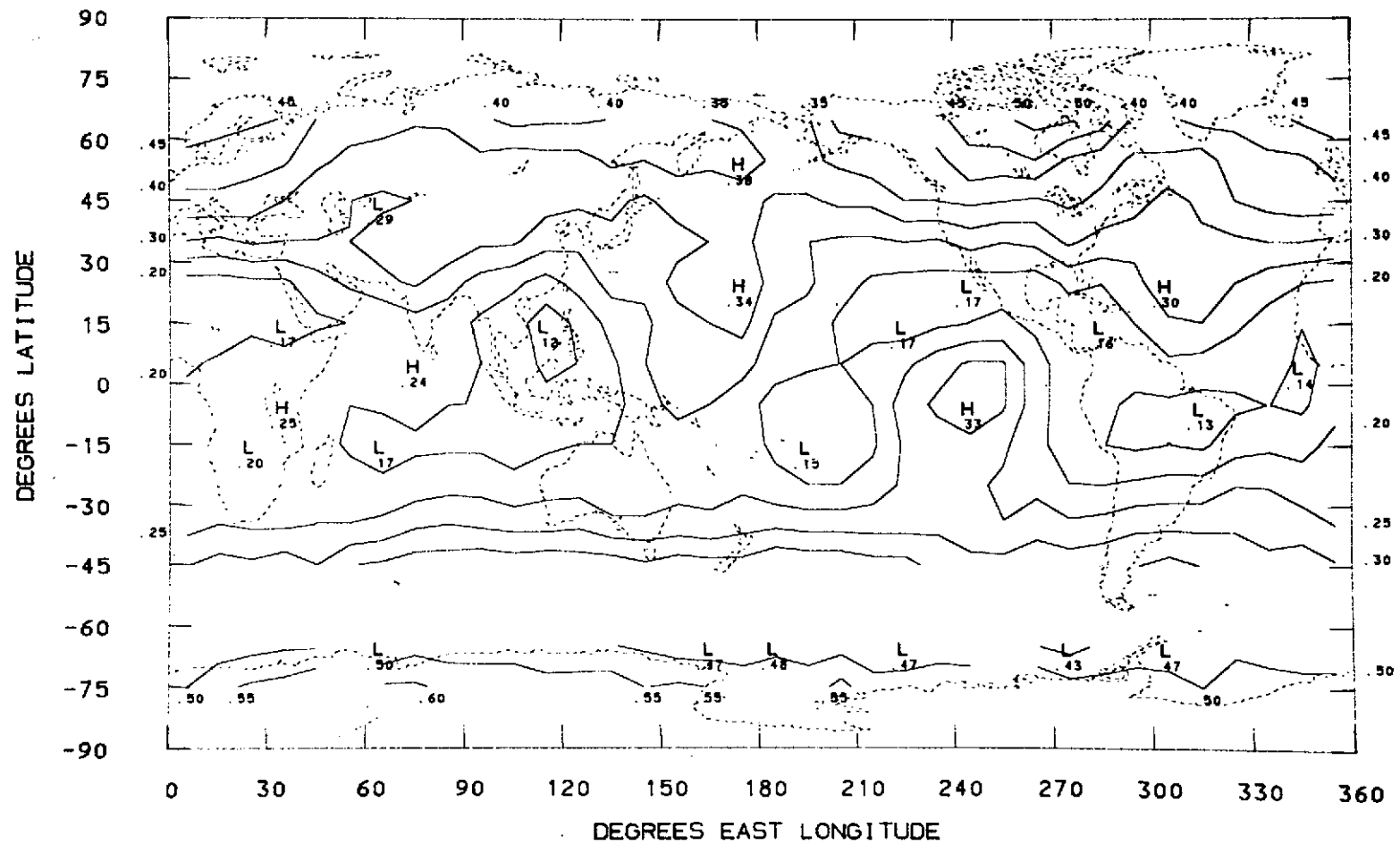
NET RADIATION (LY/MIN)
DEC JAN FEB 1964/1965



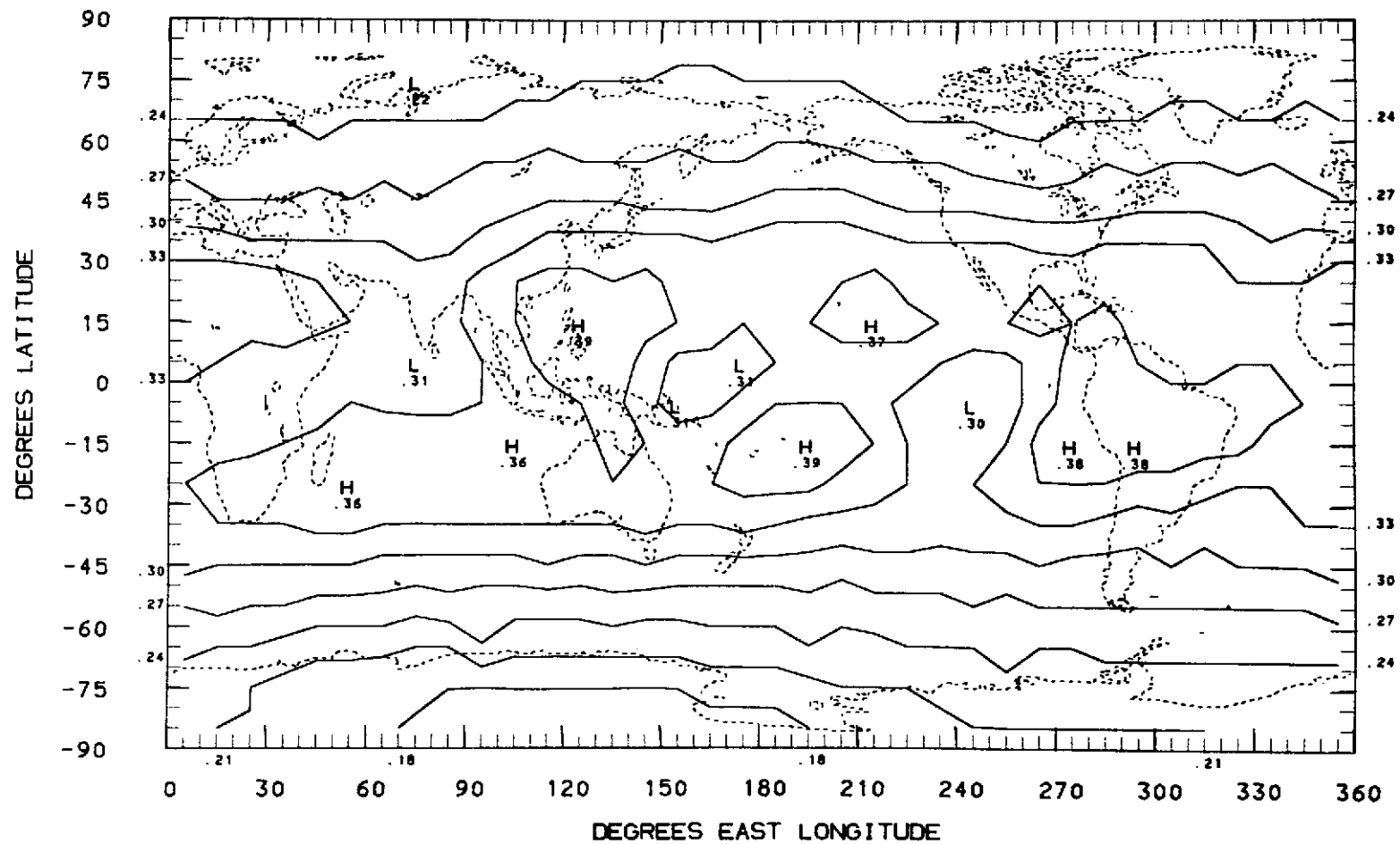
ABSORBED RADIATION (LY/MIN)
DEC JAN FEB 1964/1965



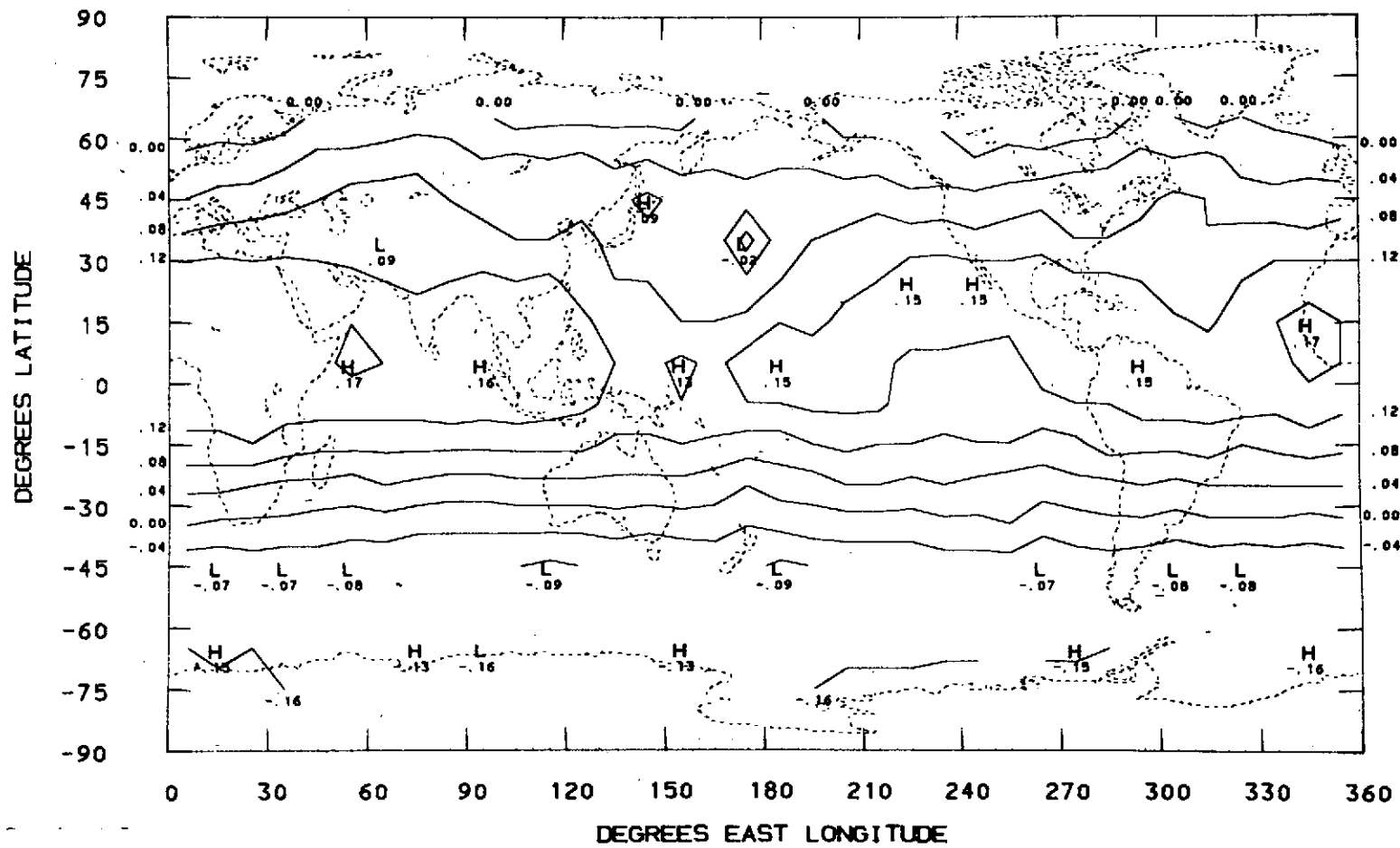
PLANETARY ALBEDO
MAR APR MAY 1965



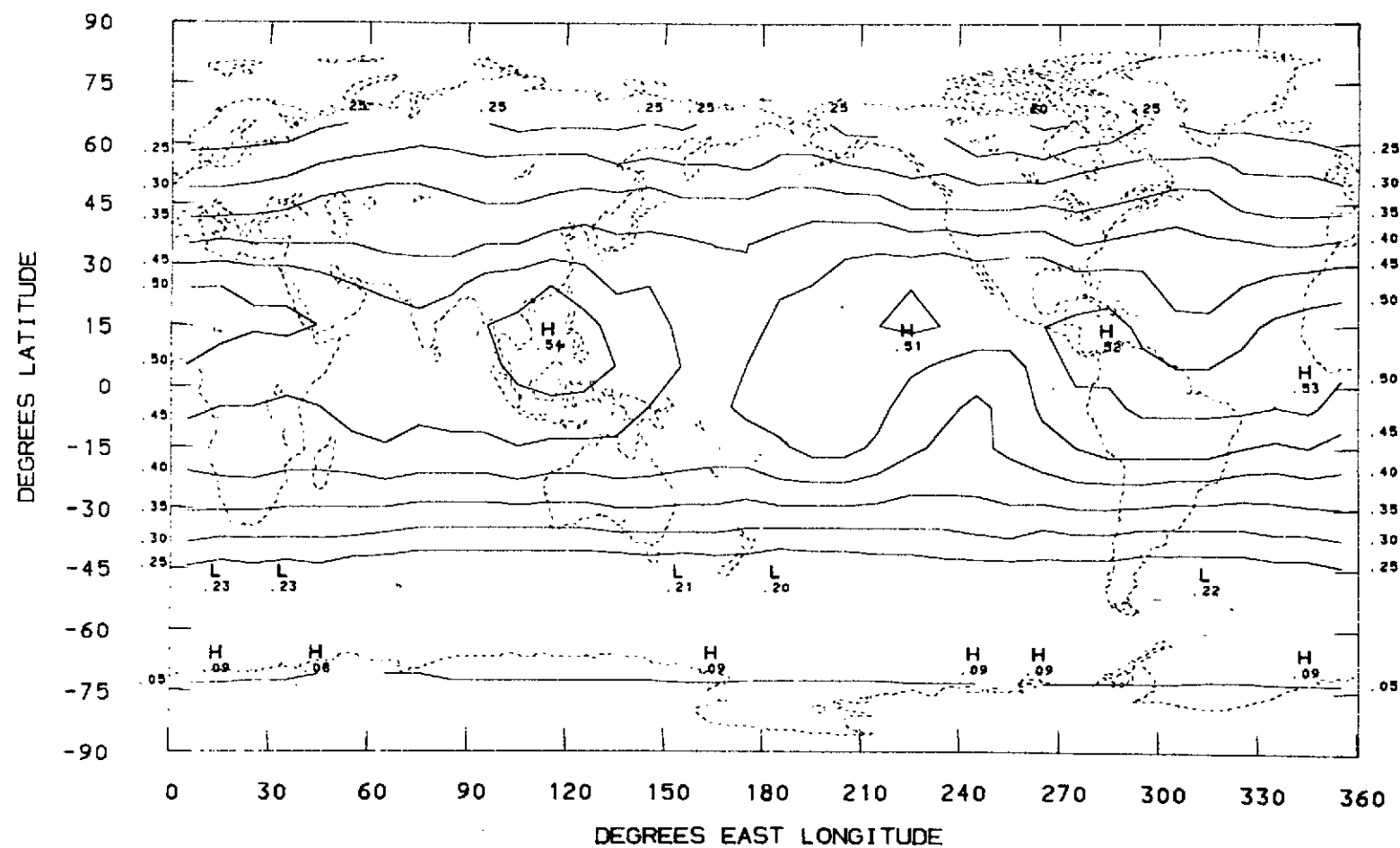
LONGWAVE RADIATION (LY/MIN)
MAR APR MAY 1965



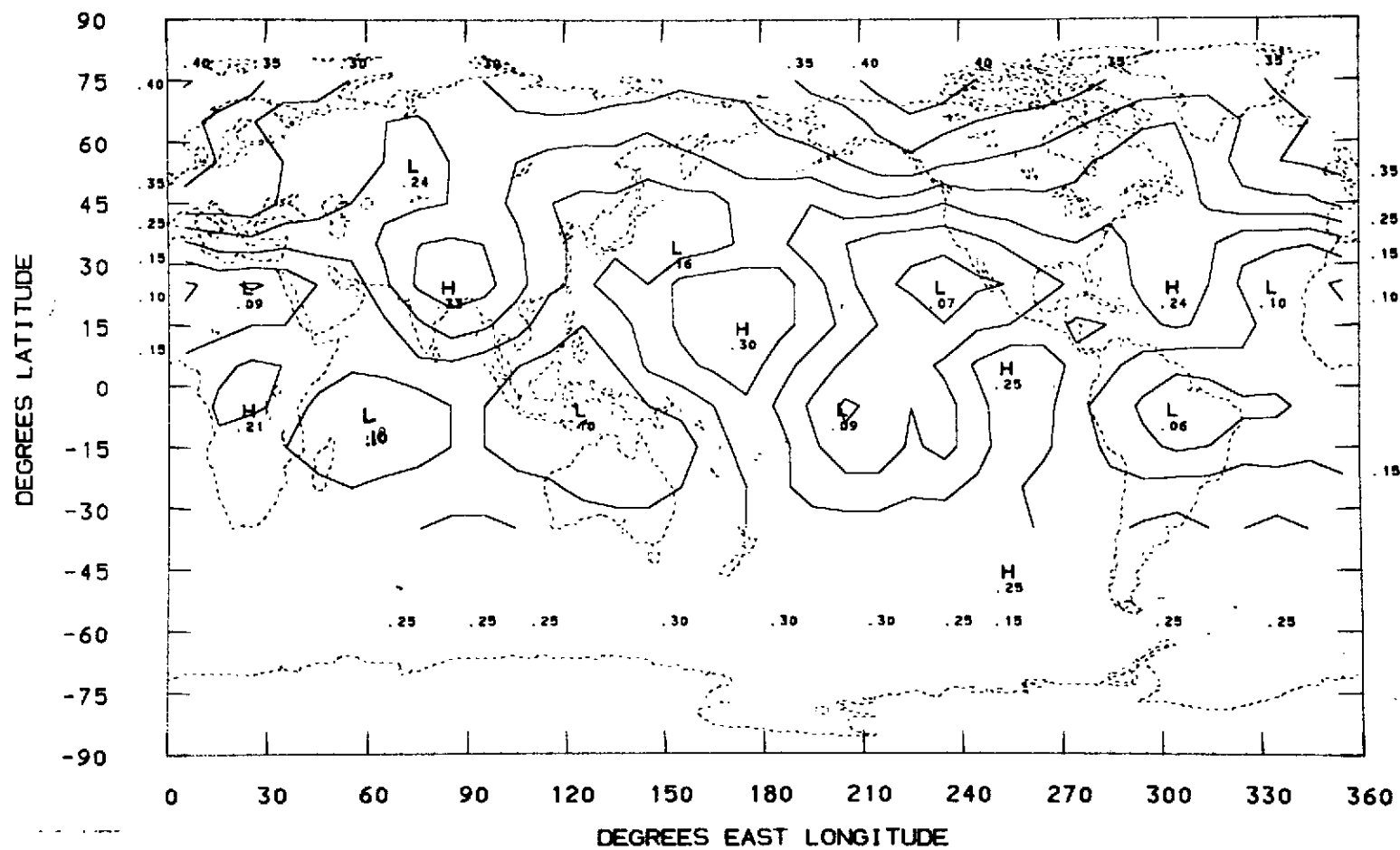
NET RADIATION (LY/MIN)
MAR APR MAY 1965



ABSORBED RADIATION (LY/MIN)
MAR APR MAY 1965

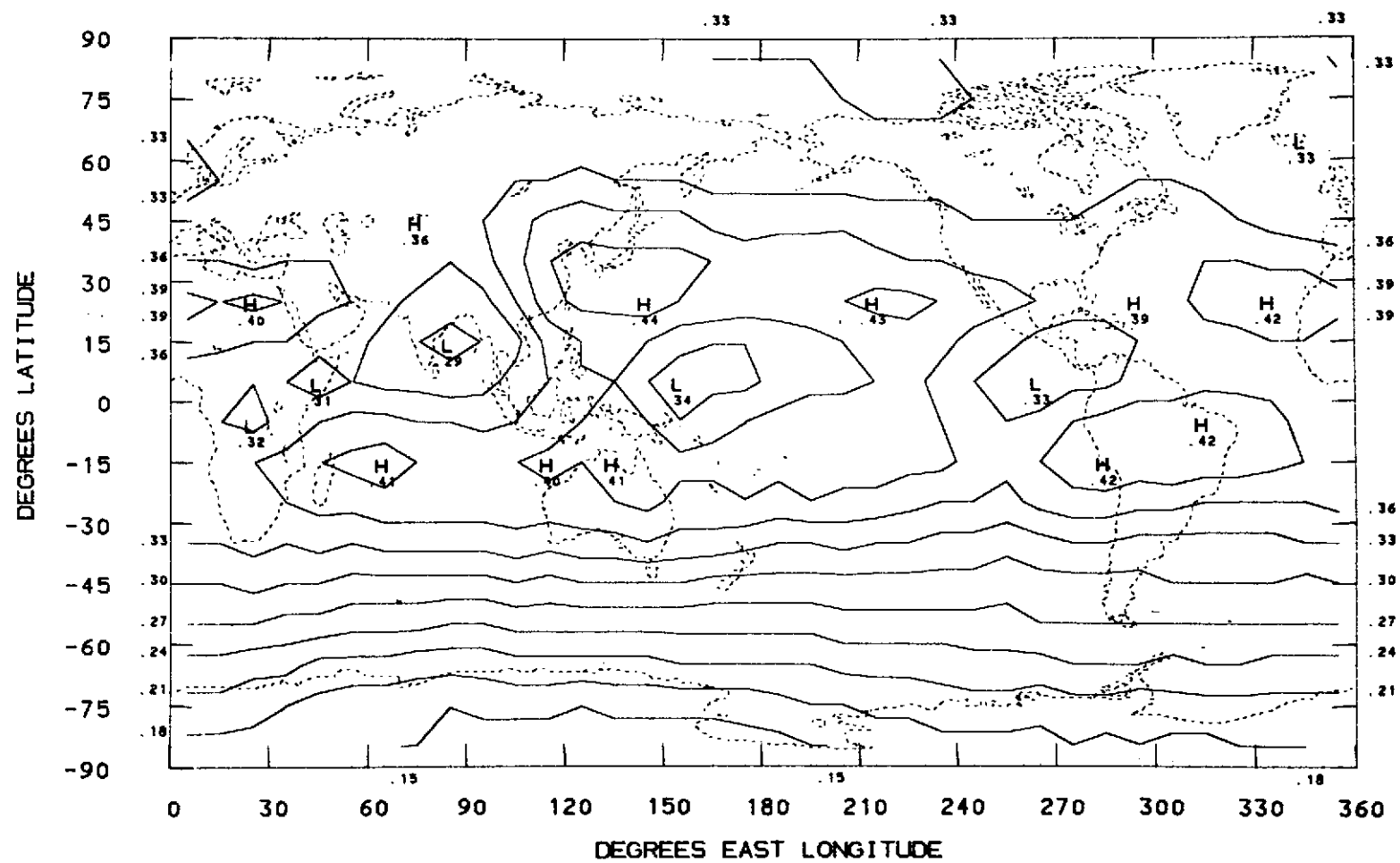


PLANETARY ALBEDO
JUN JUL AUG 1965

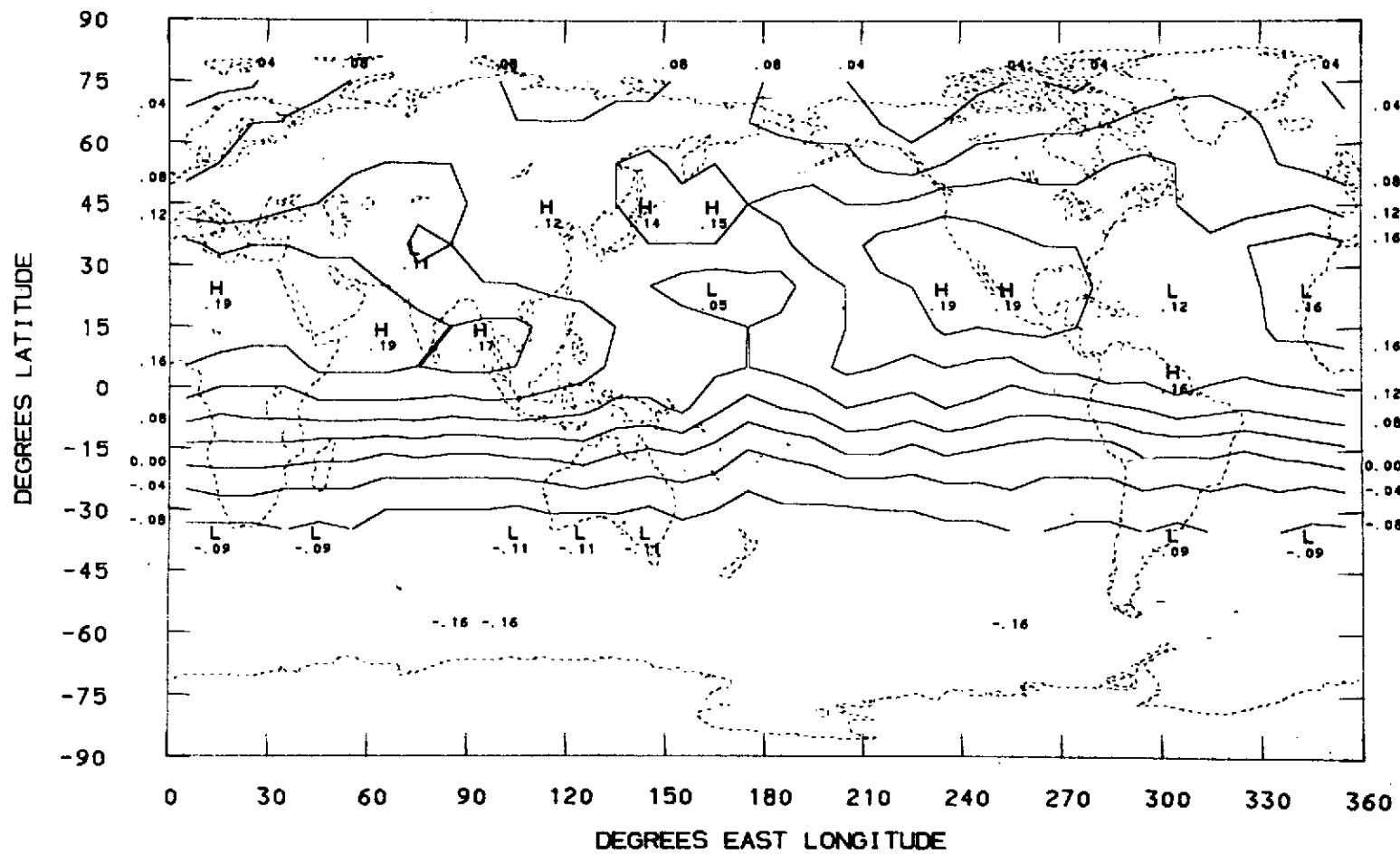


LONGWAVE RADIATION (LY/MIN)

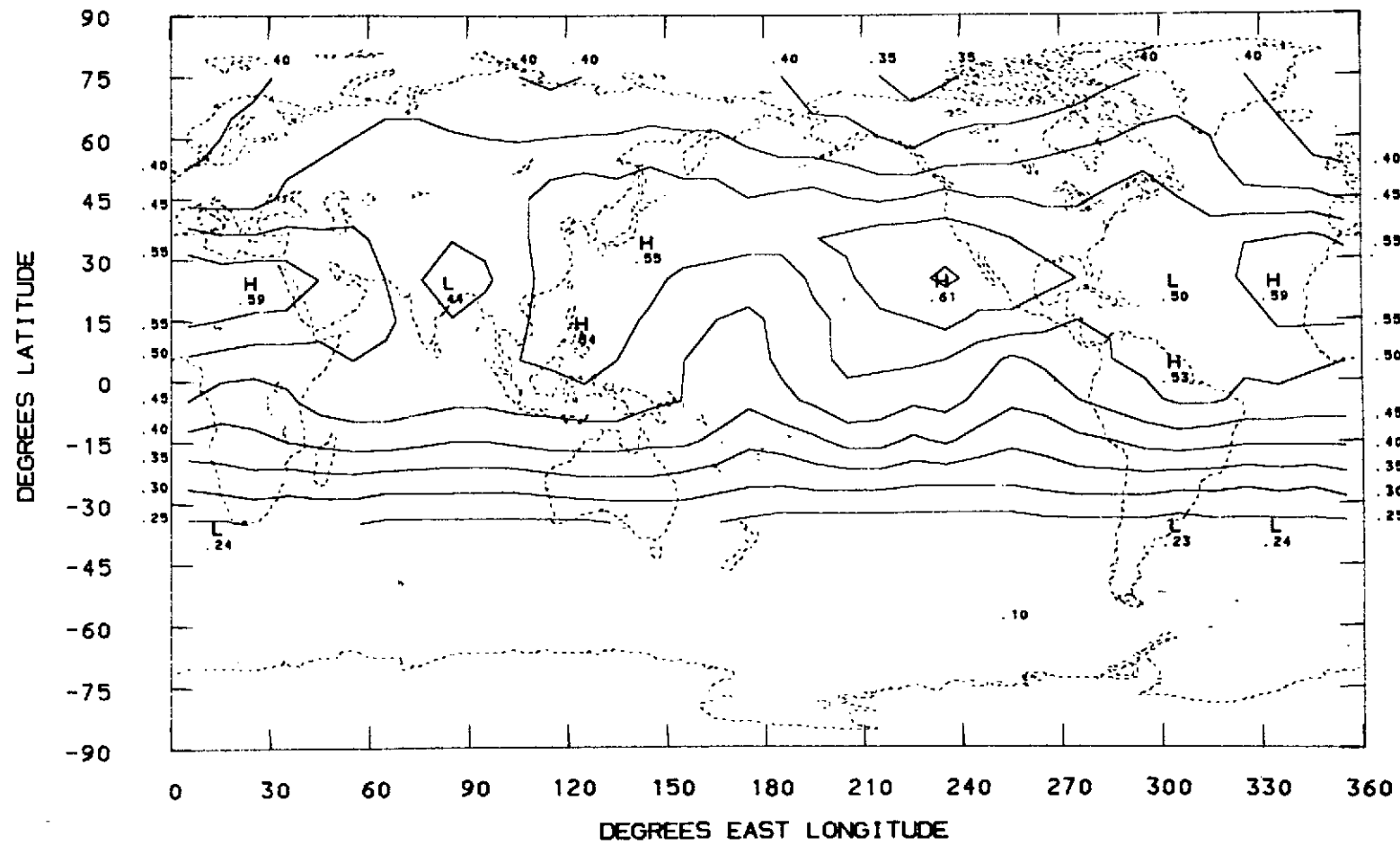
JUN JUL AUG 1965



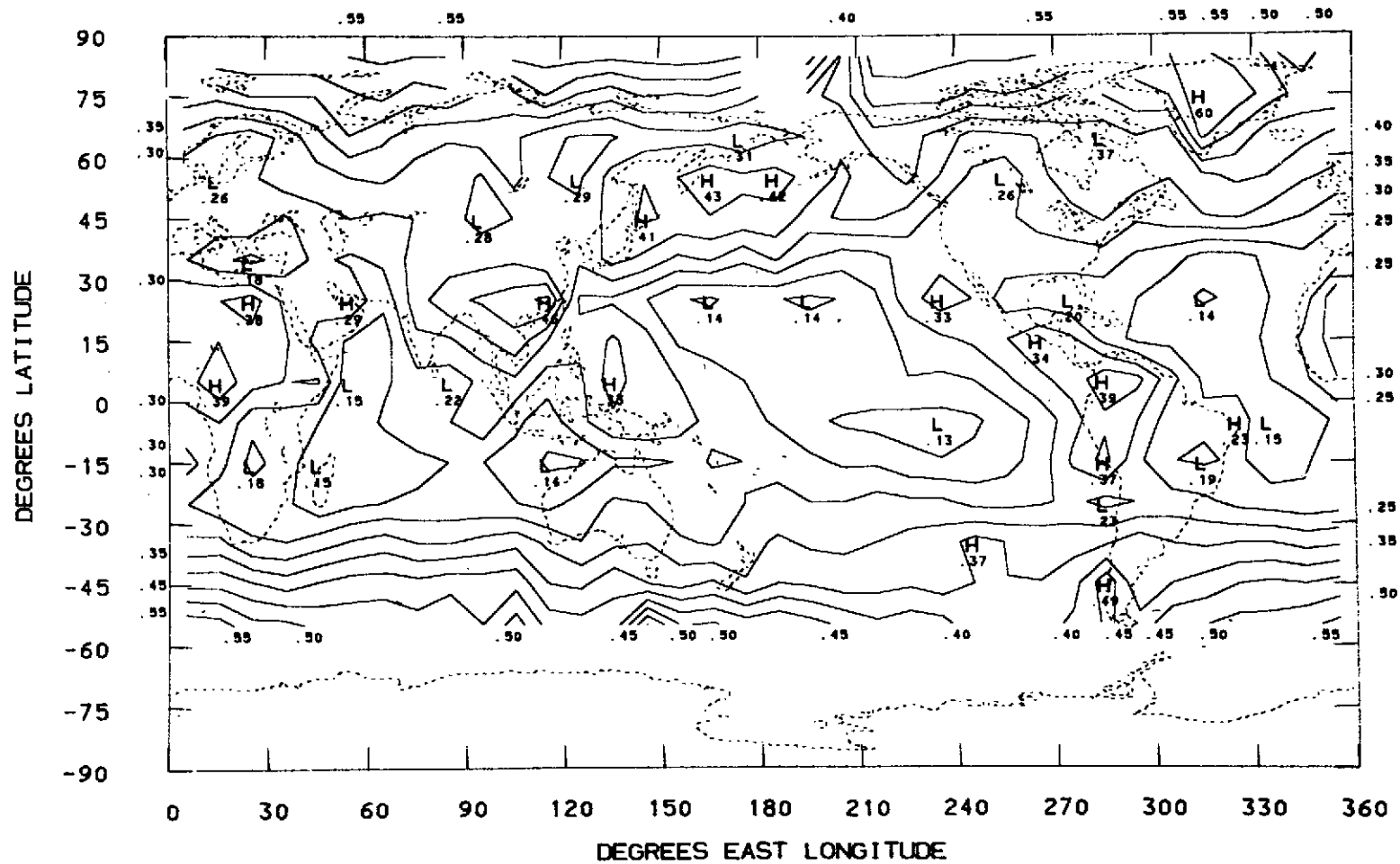
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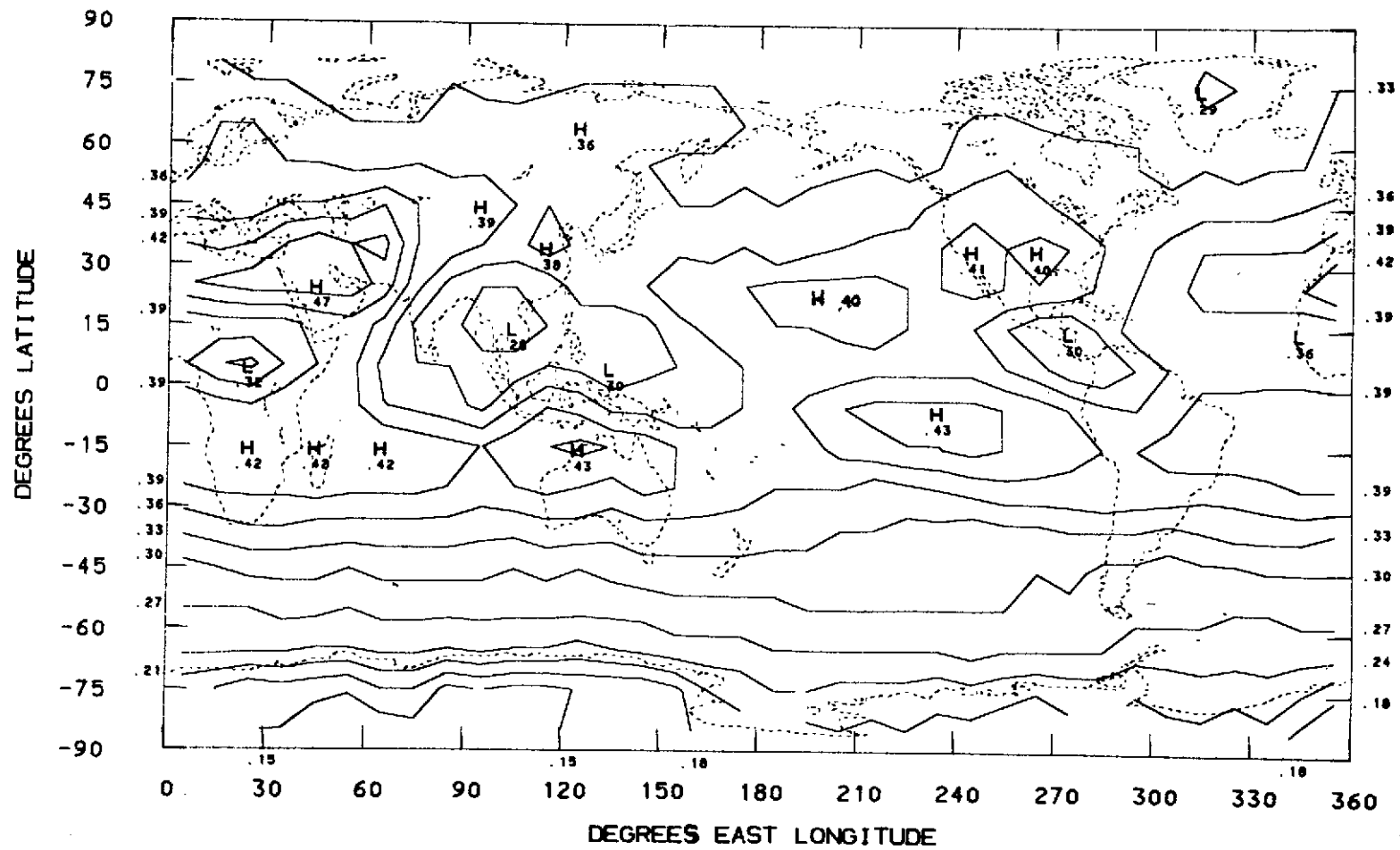
ABSORBED RADIATION (LY/MIN)
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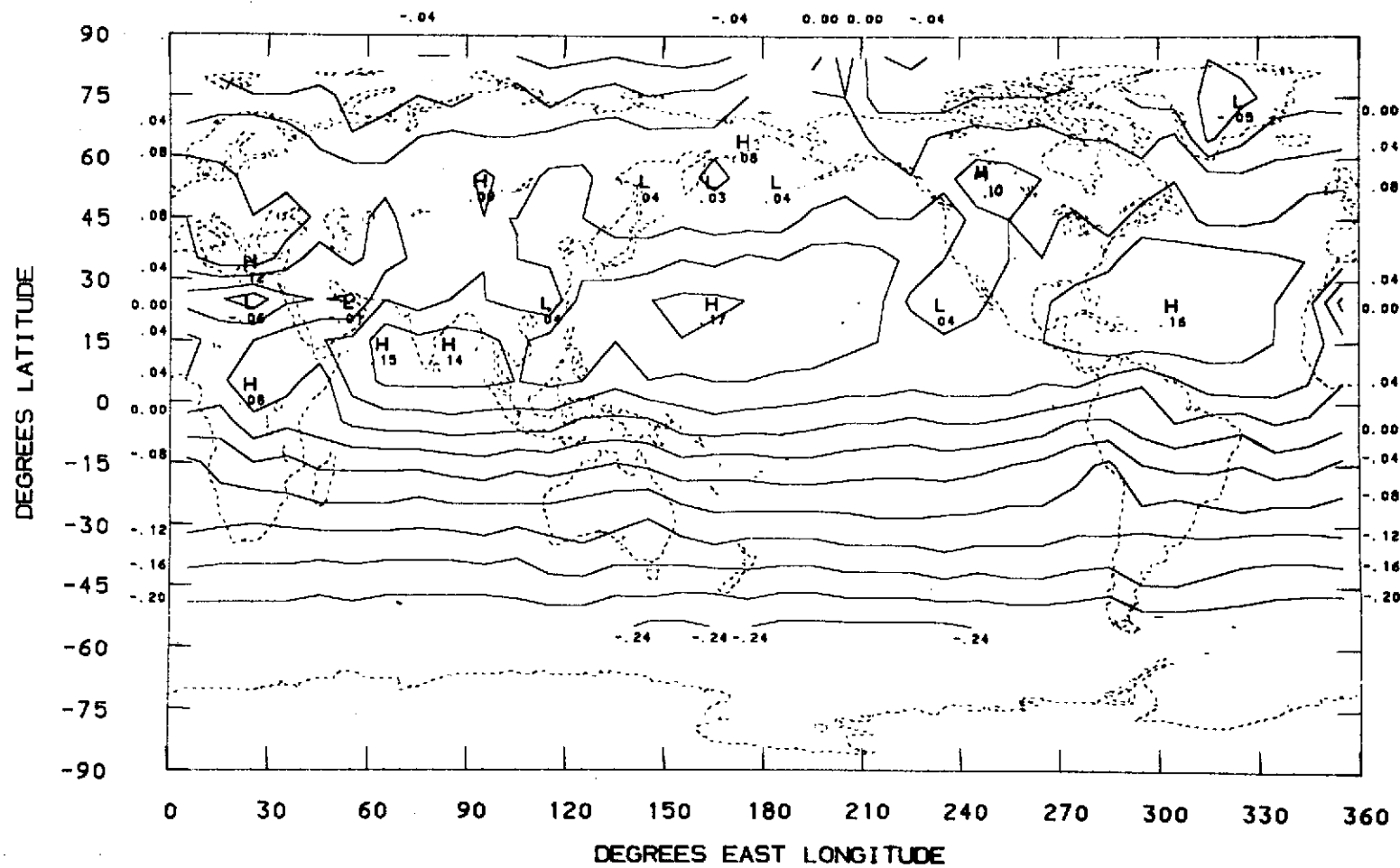
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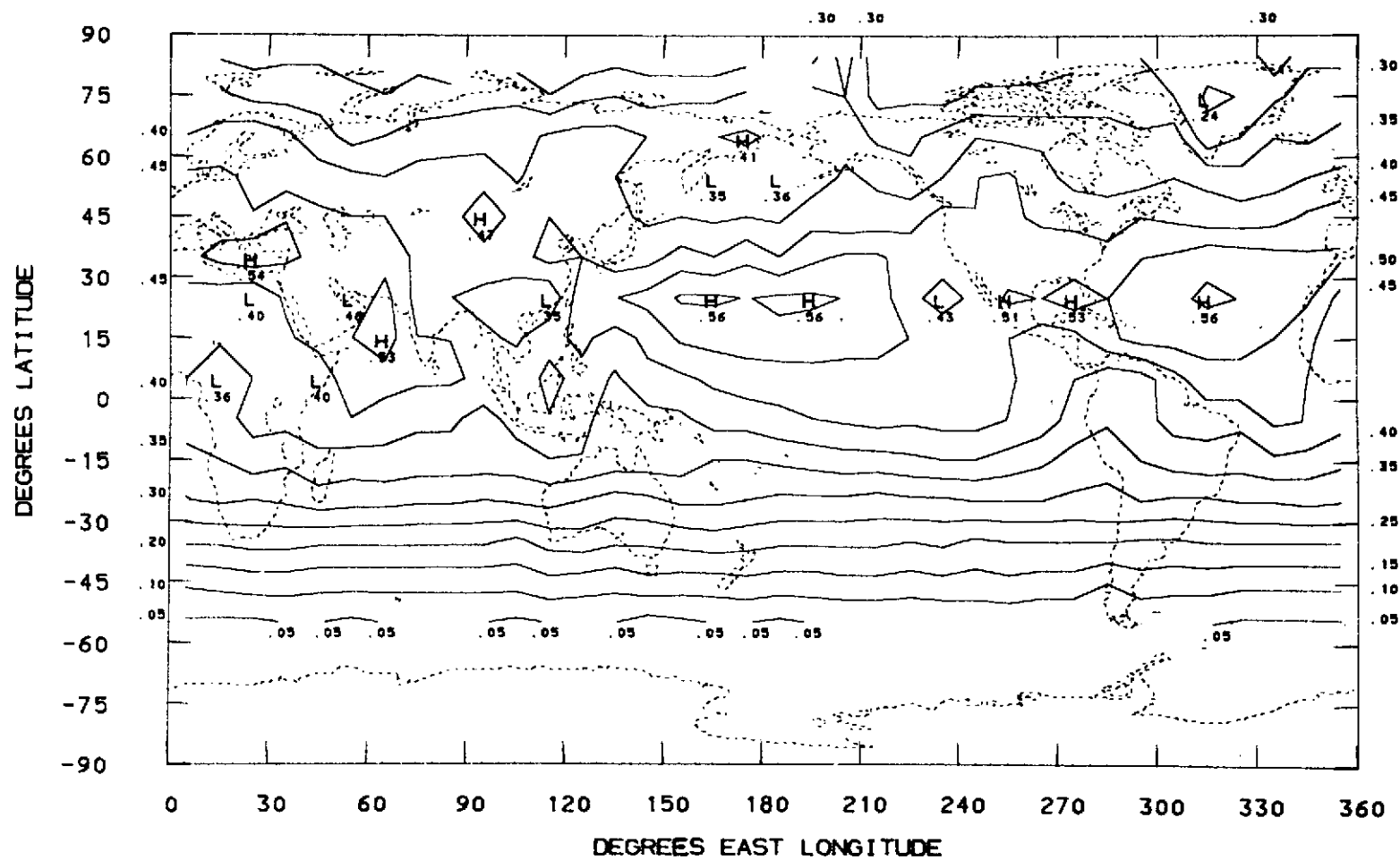
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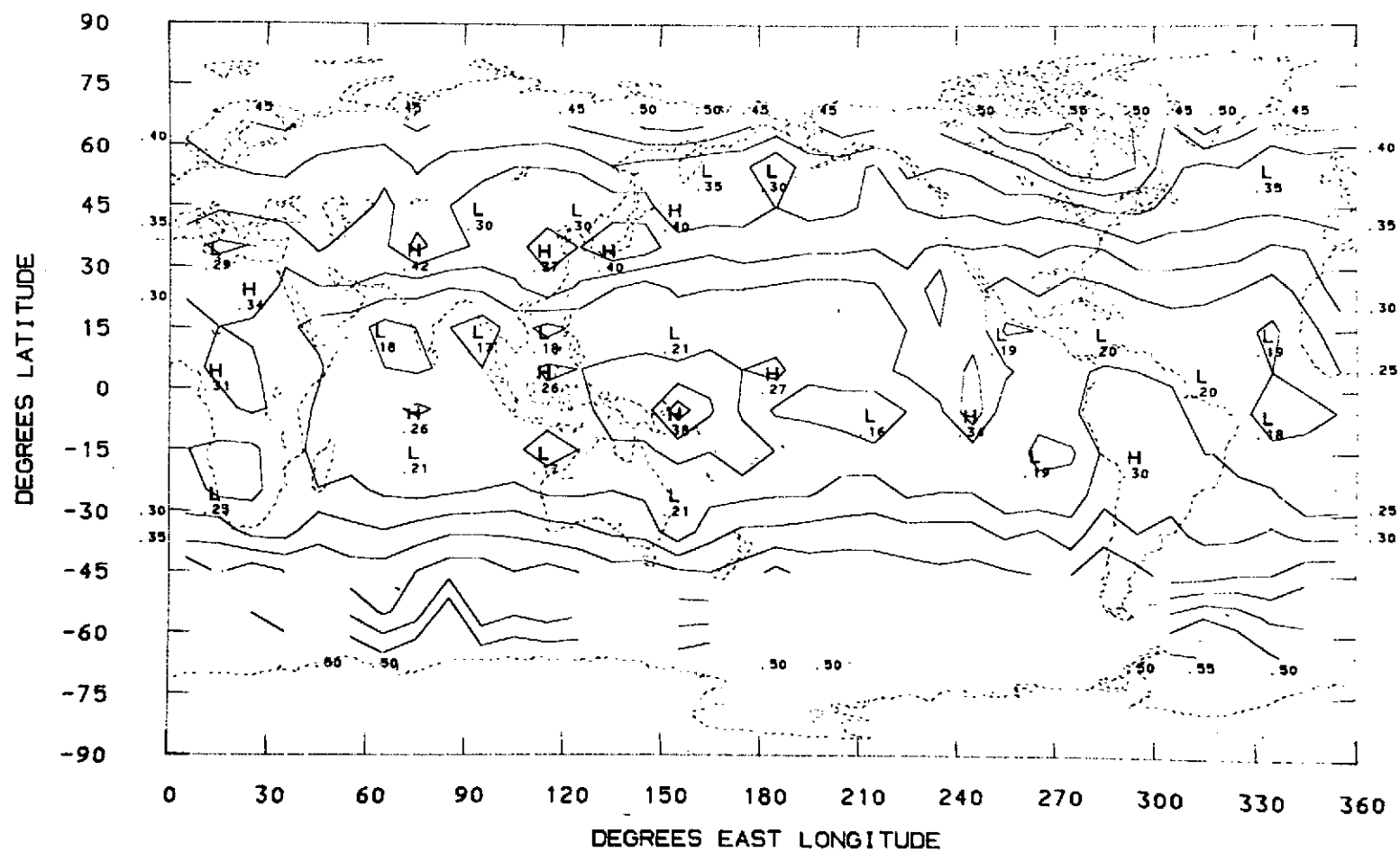
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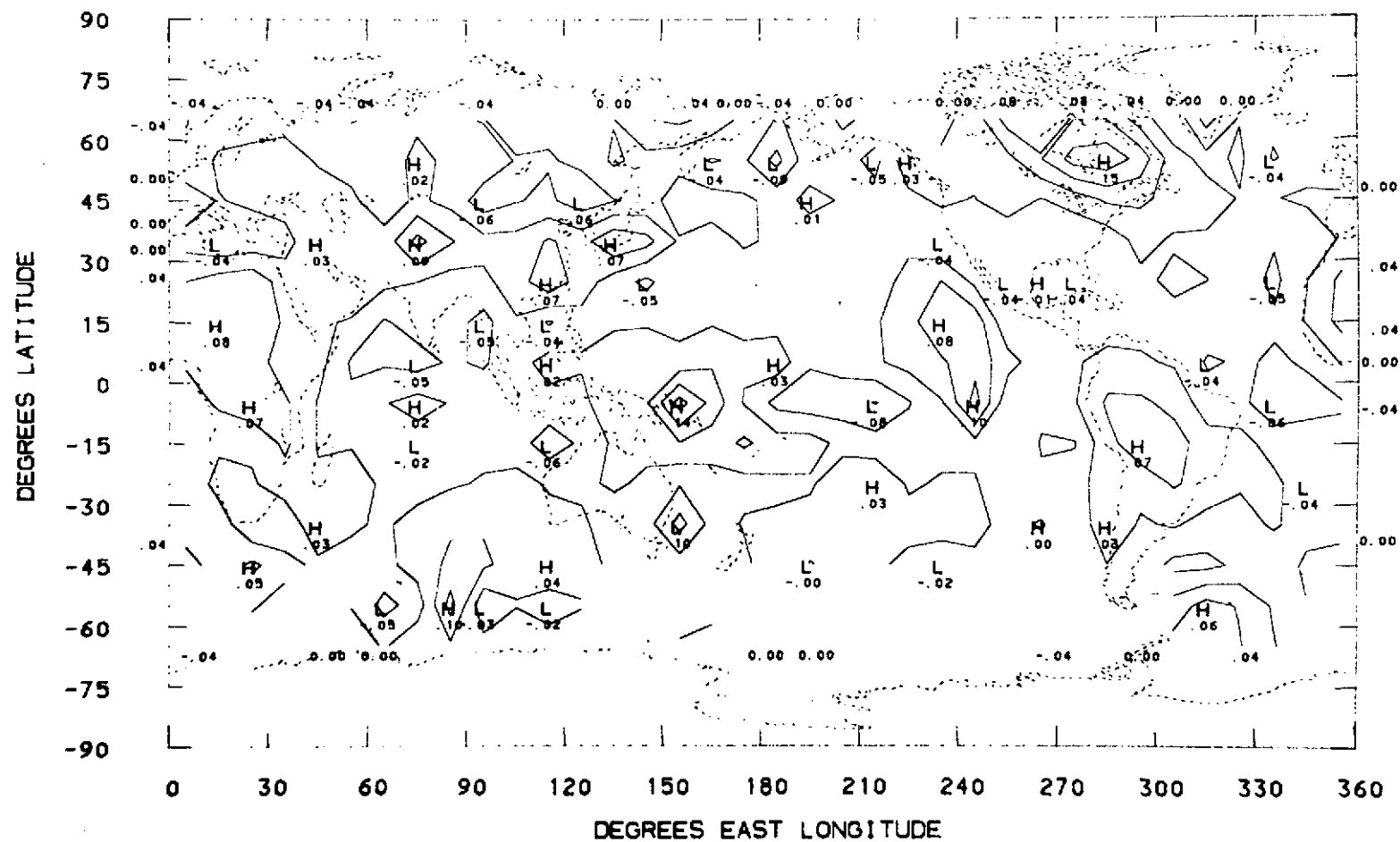
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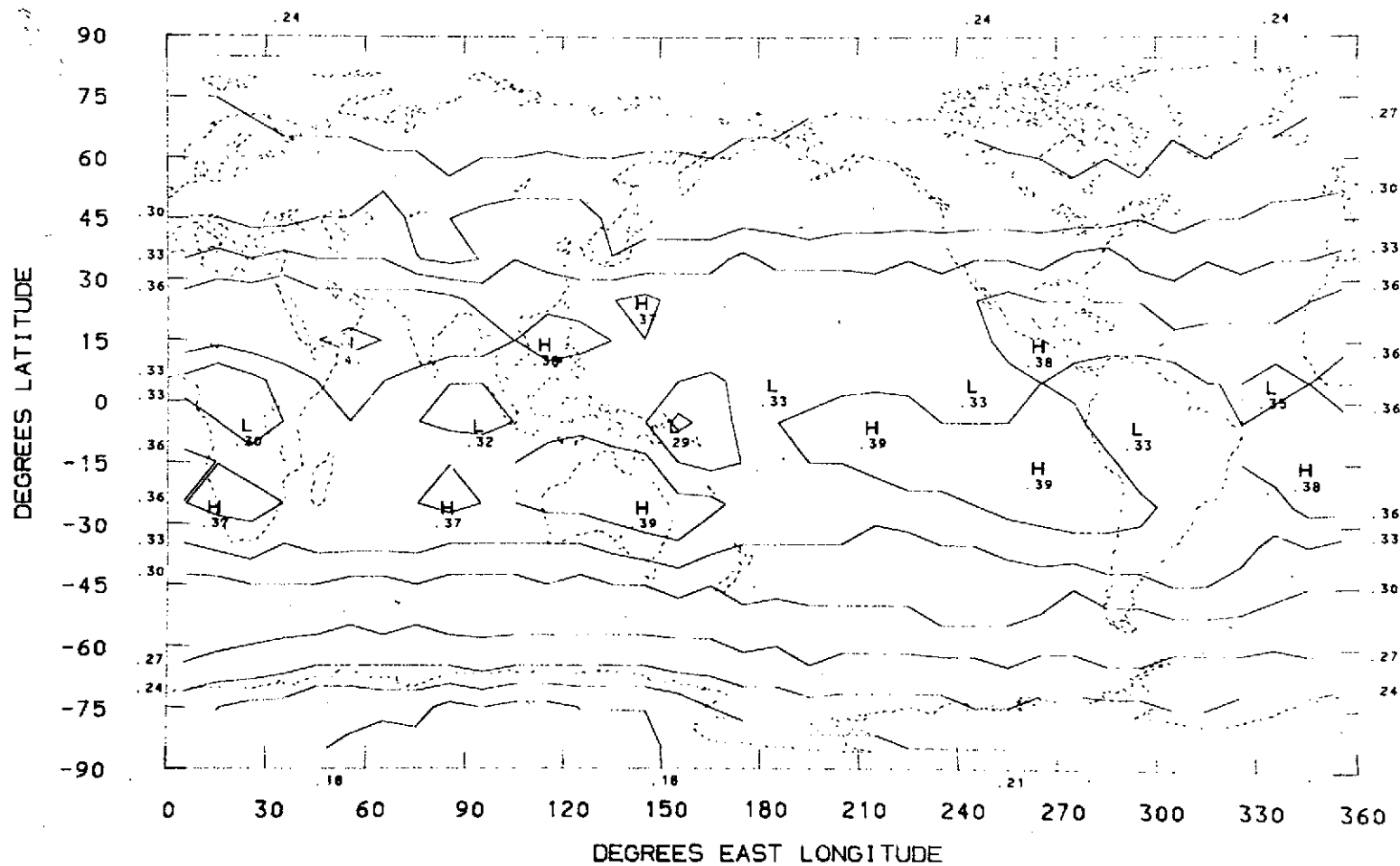
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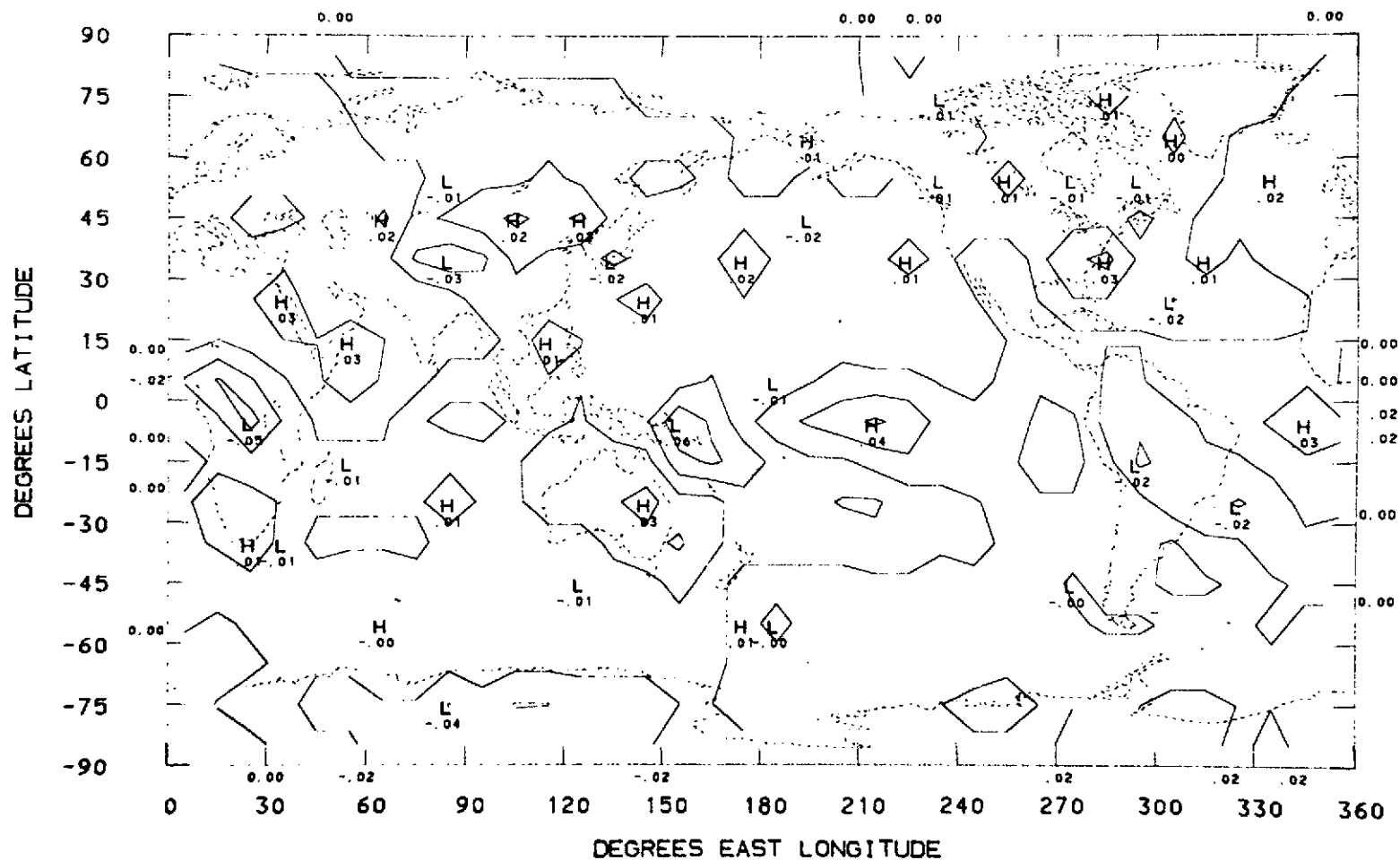
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LONGWAVE RADIATION (LY/MIN)
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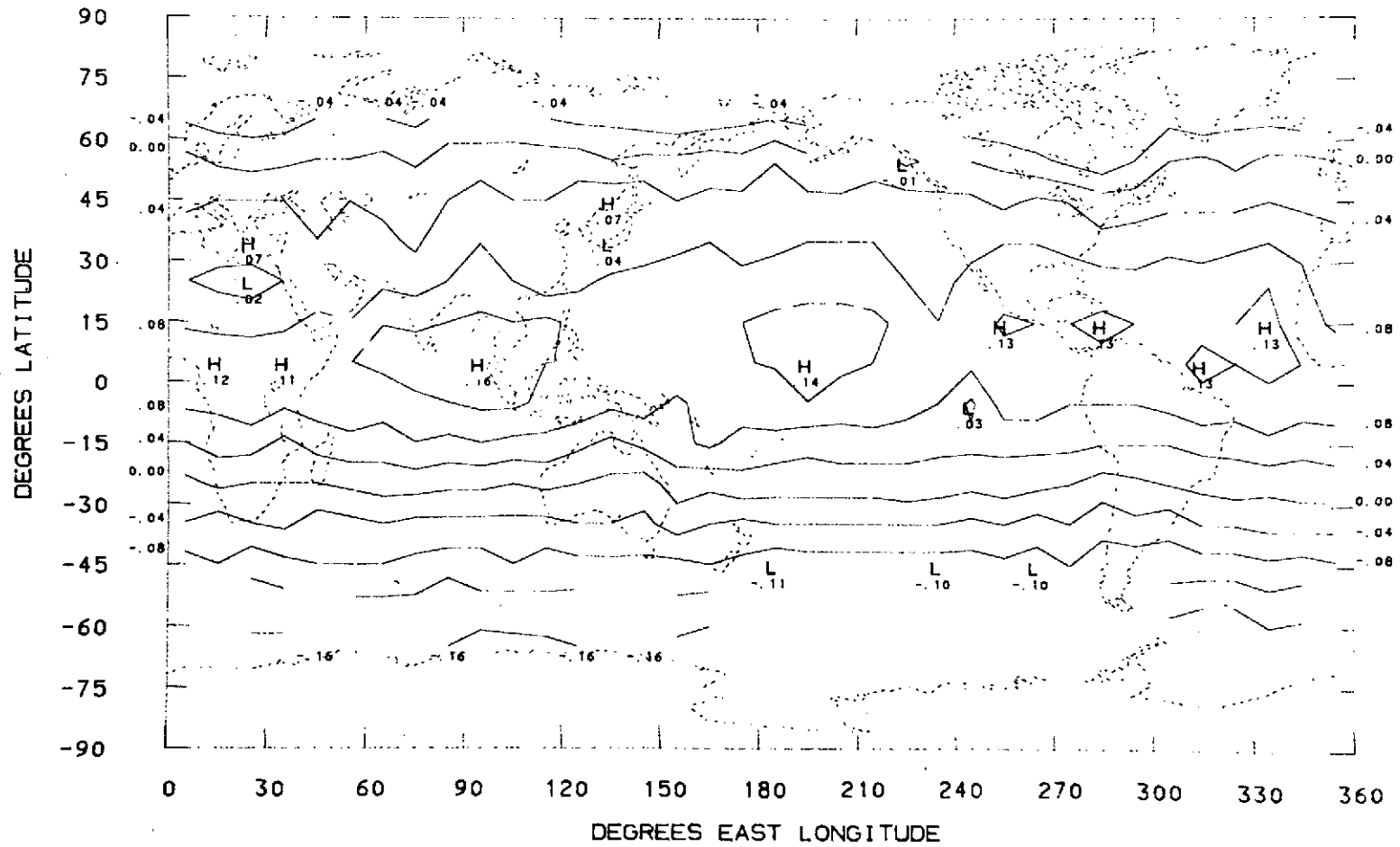


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 DEVIATION FROM ZONAL AVG. MEAN MAR APR MAY

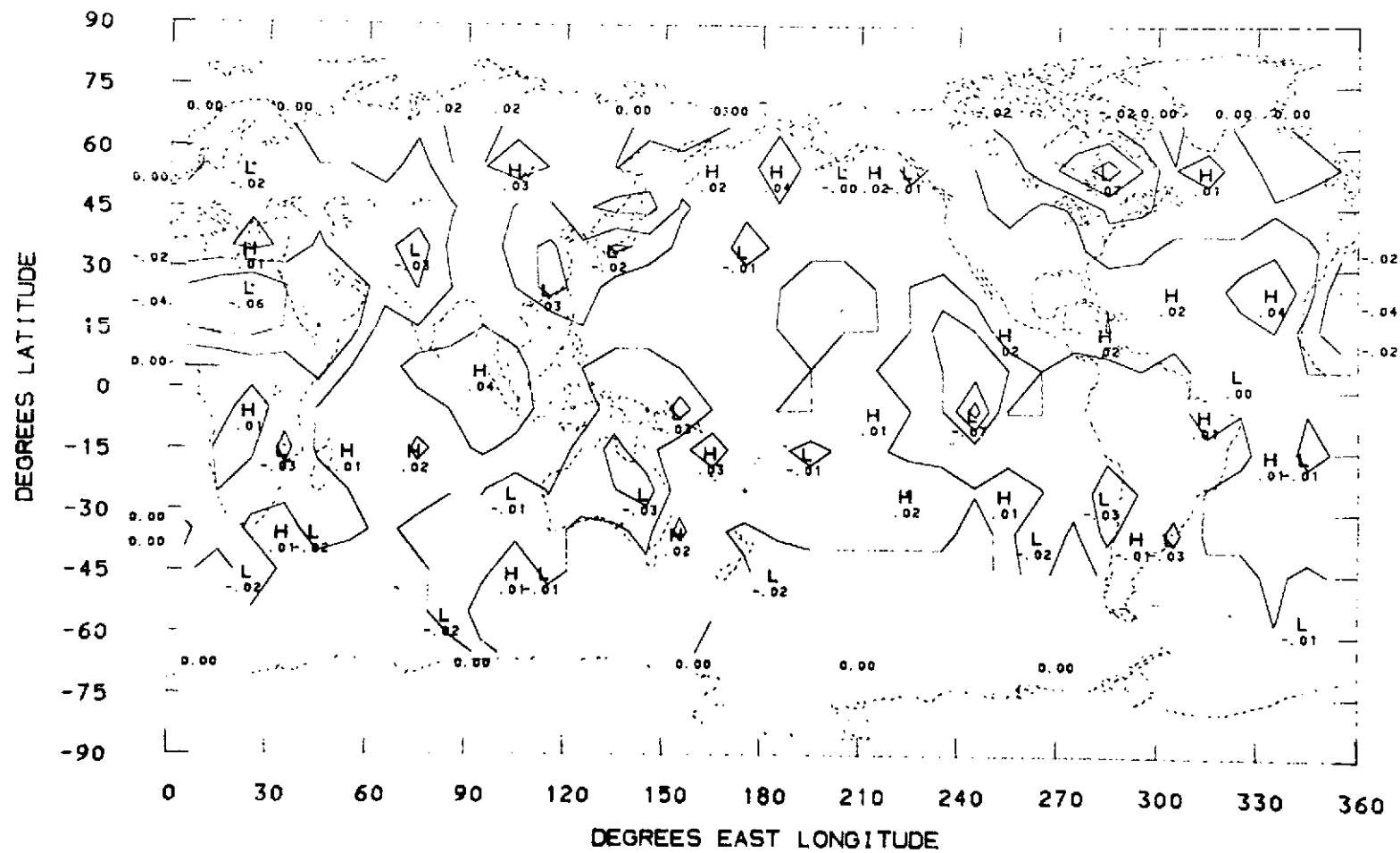


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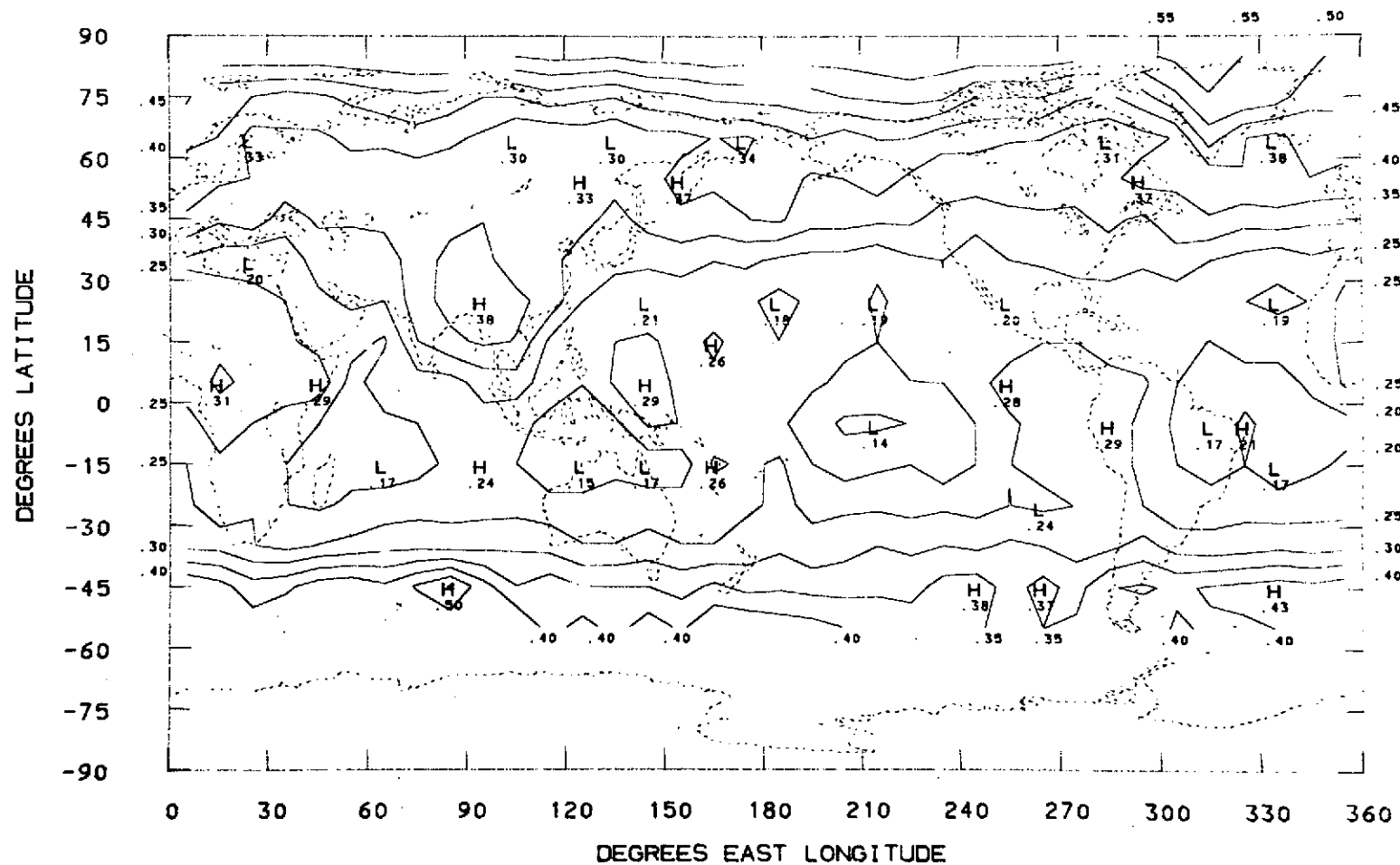
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MEAN MAR APR MAY



NET RADIATION (LY/MIN)
DEVIATION FROM ZONAL AVG. MEAN MAR APR MAY

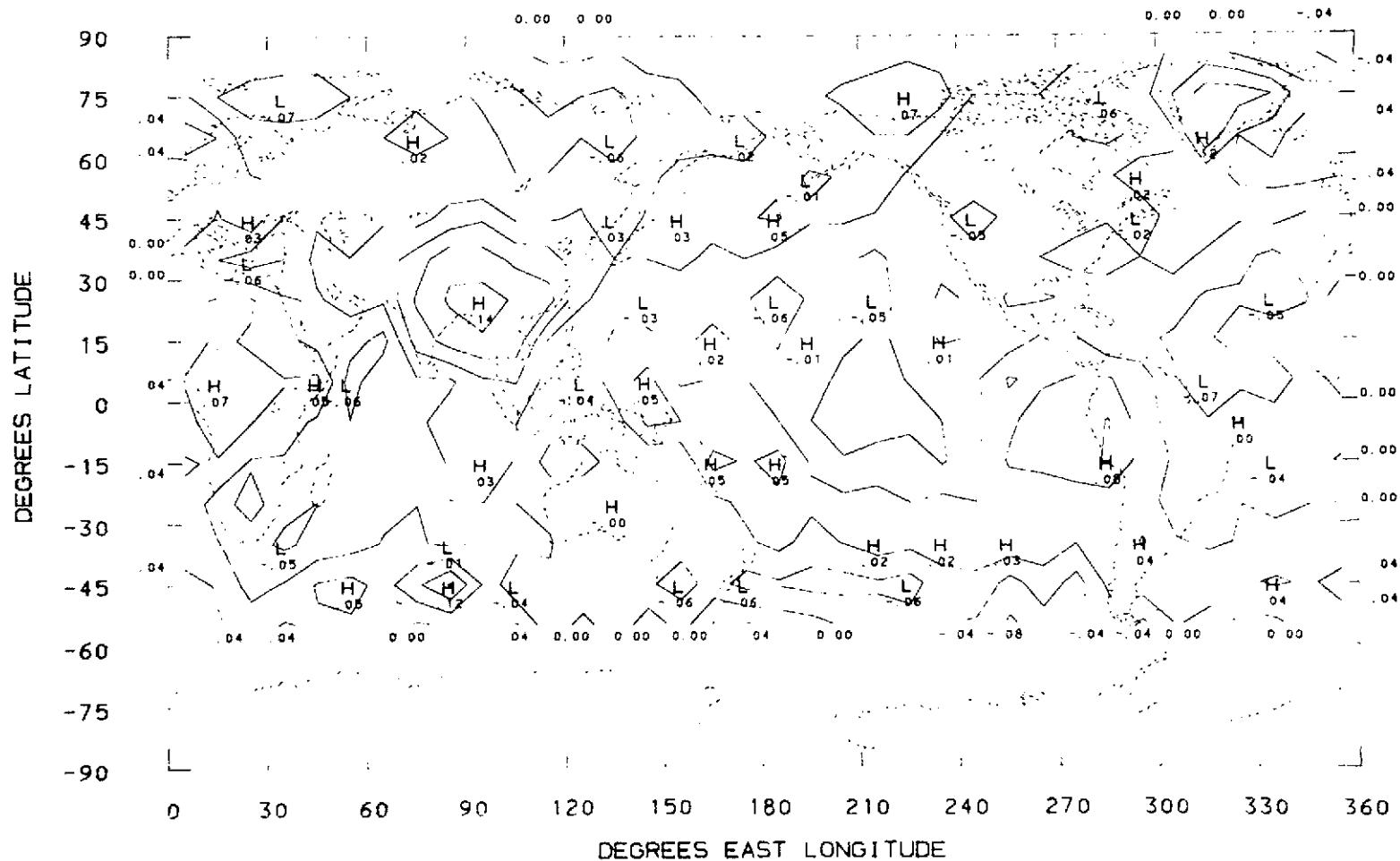


PLANETARY ALBEDO
MEAN JUN JUL AUG



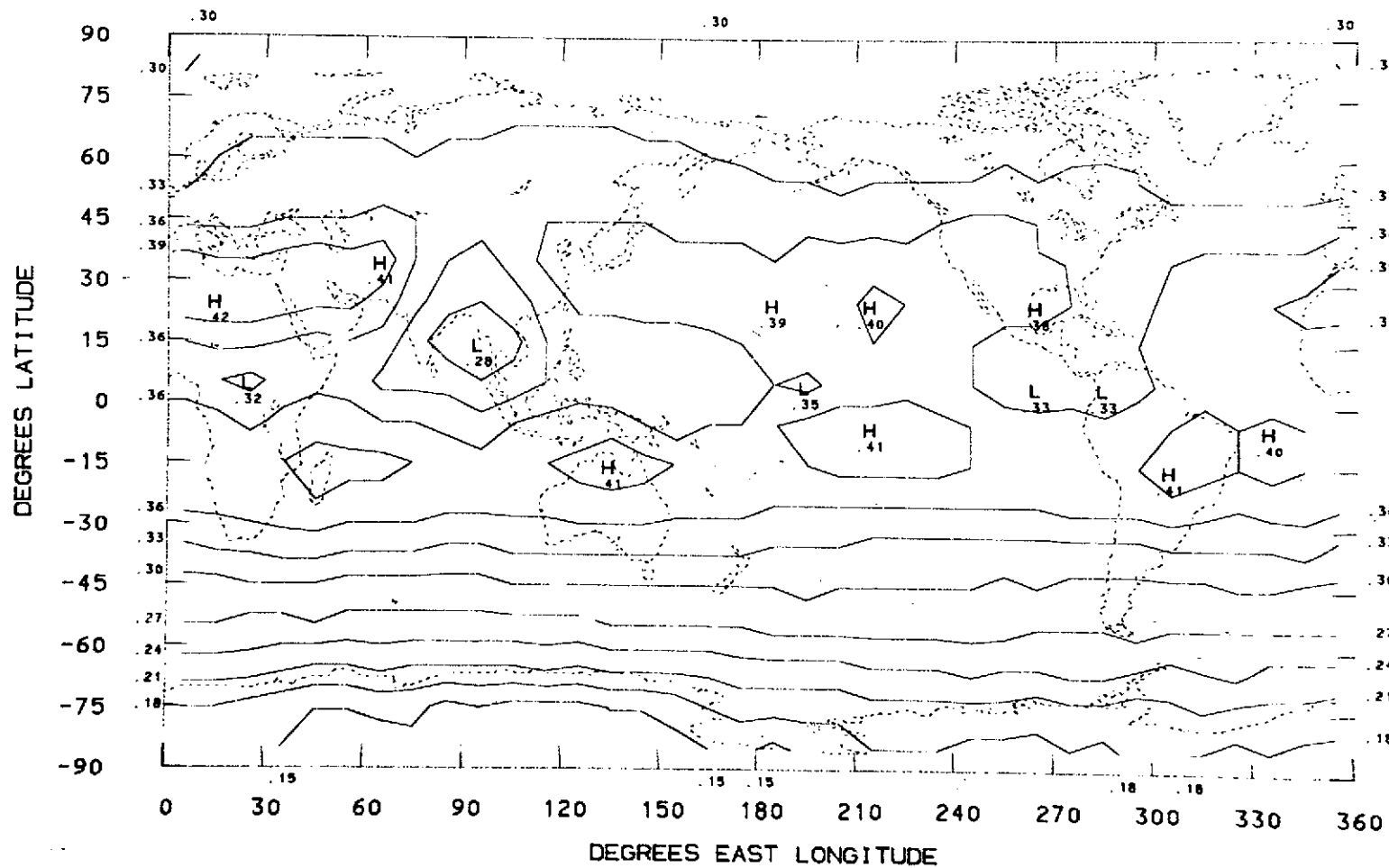
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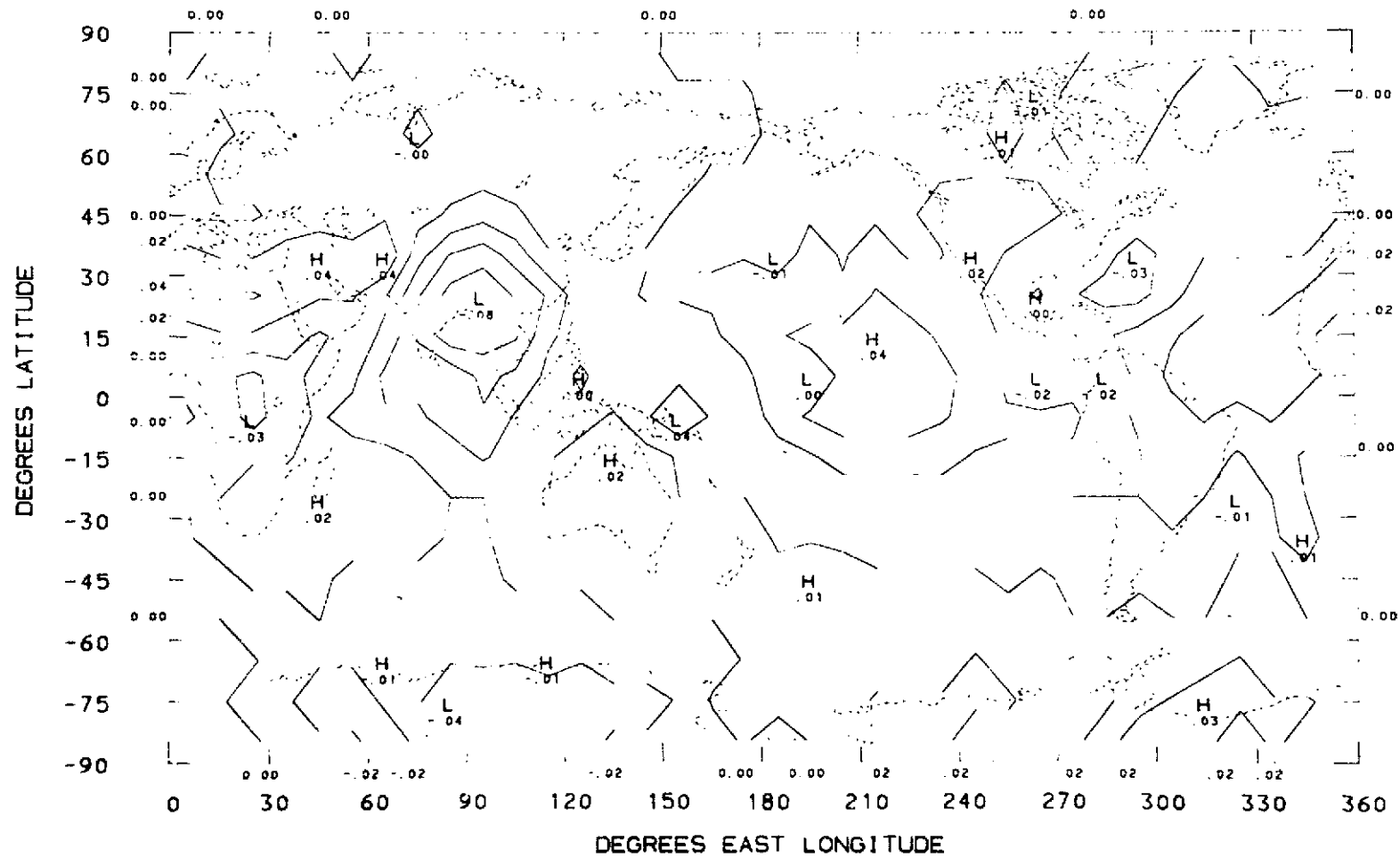


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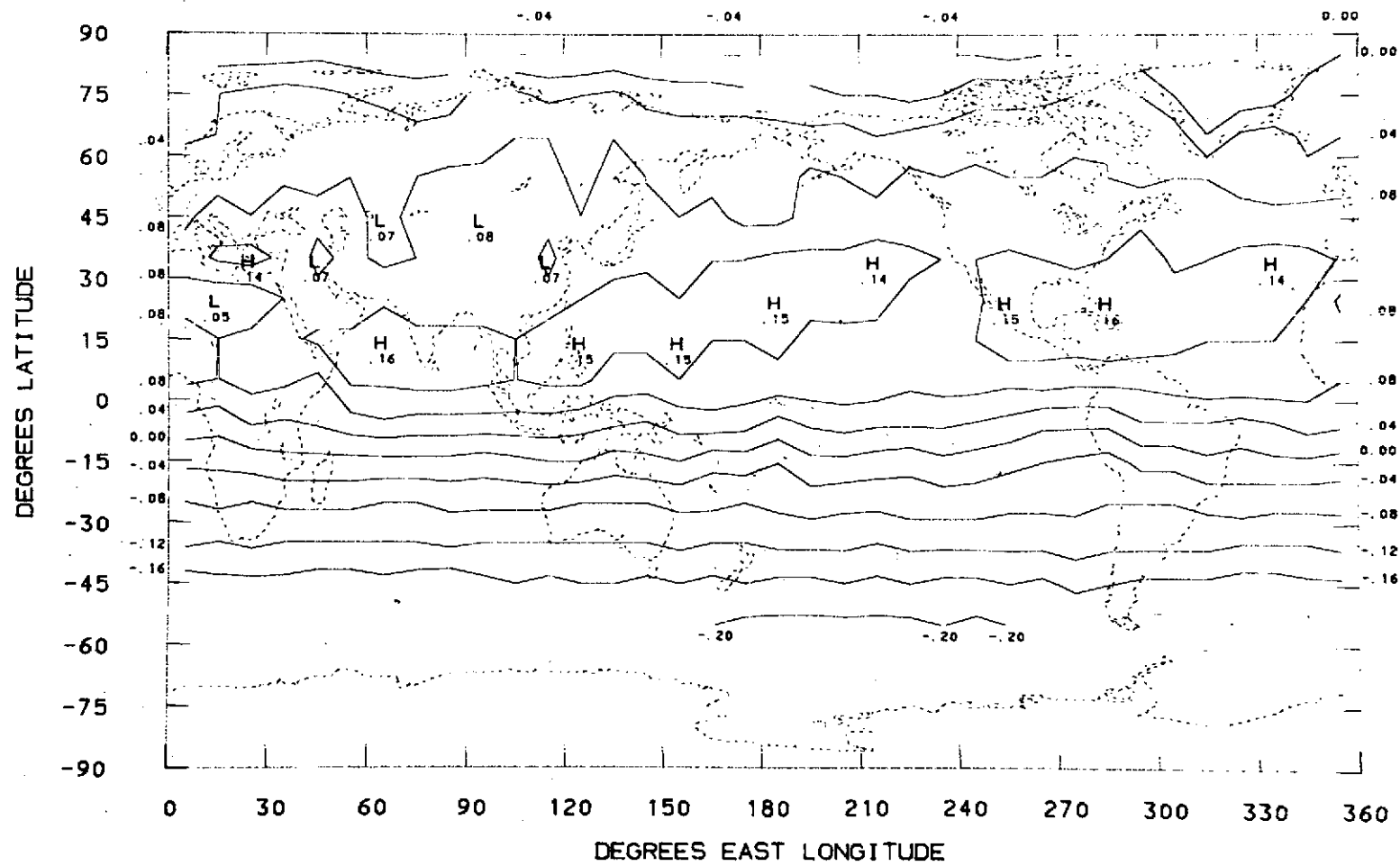
LONGWAVE RADIATION (LY/MIN)
MEAN JUN JUL AUG



LONGWAVE RADIATION (LY/MIN)
DEVIATION FROM ZONAL AVG. MEAN JUN JUL AUG



NET RADIATION (LY/MIN)
MEAN JUN JUL AUG



ABSORBED RADIATION (LY/MIN)
MEAN JUN JUL AUG

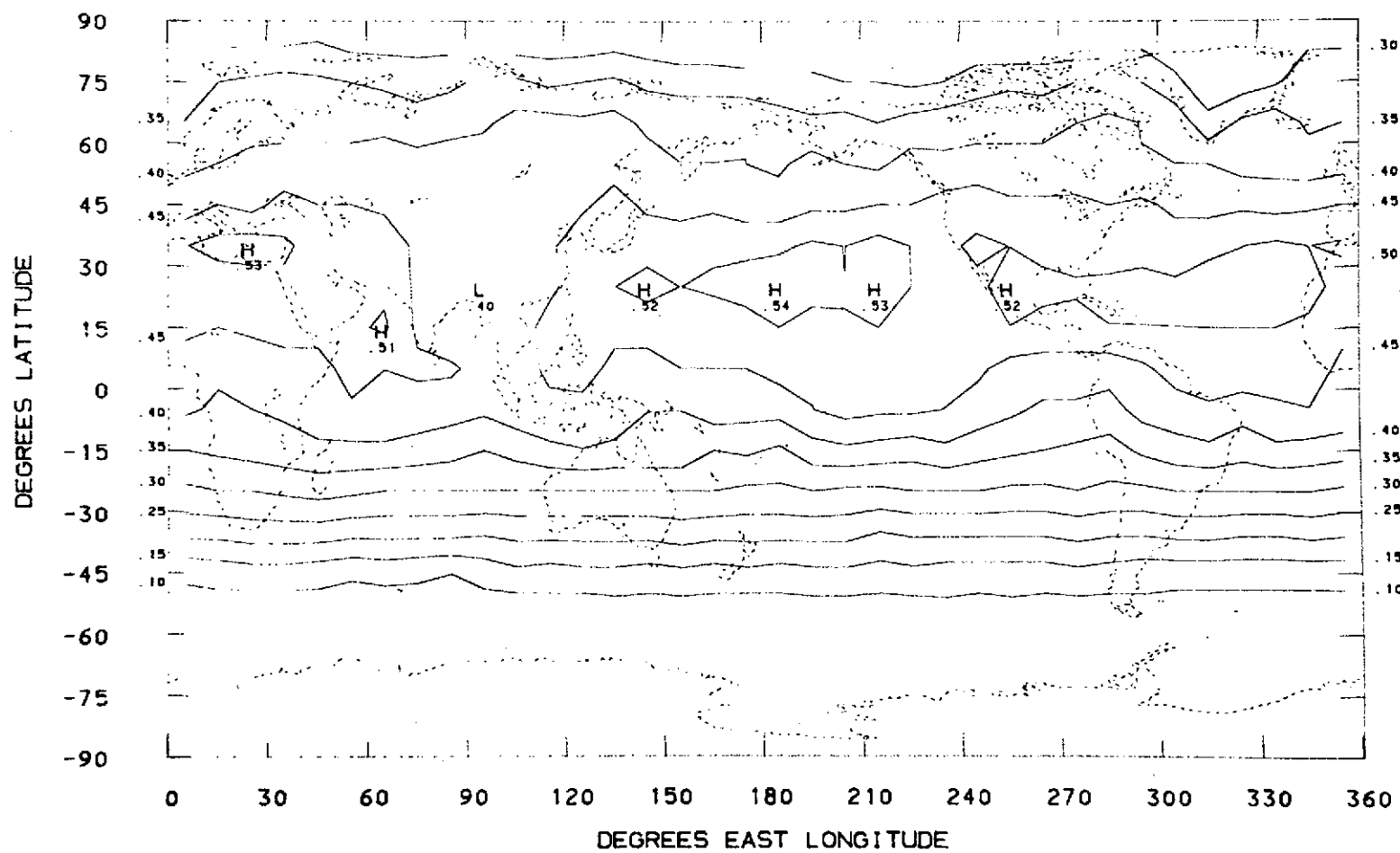
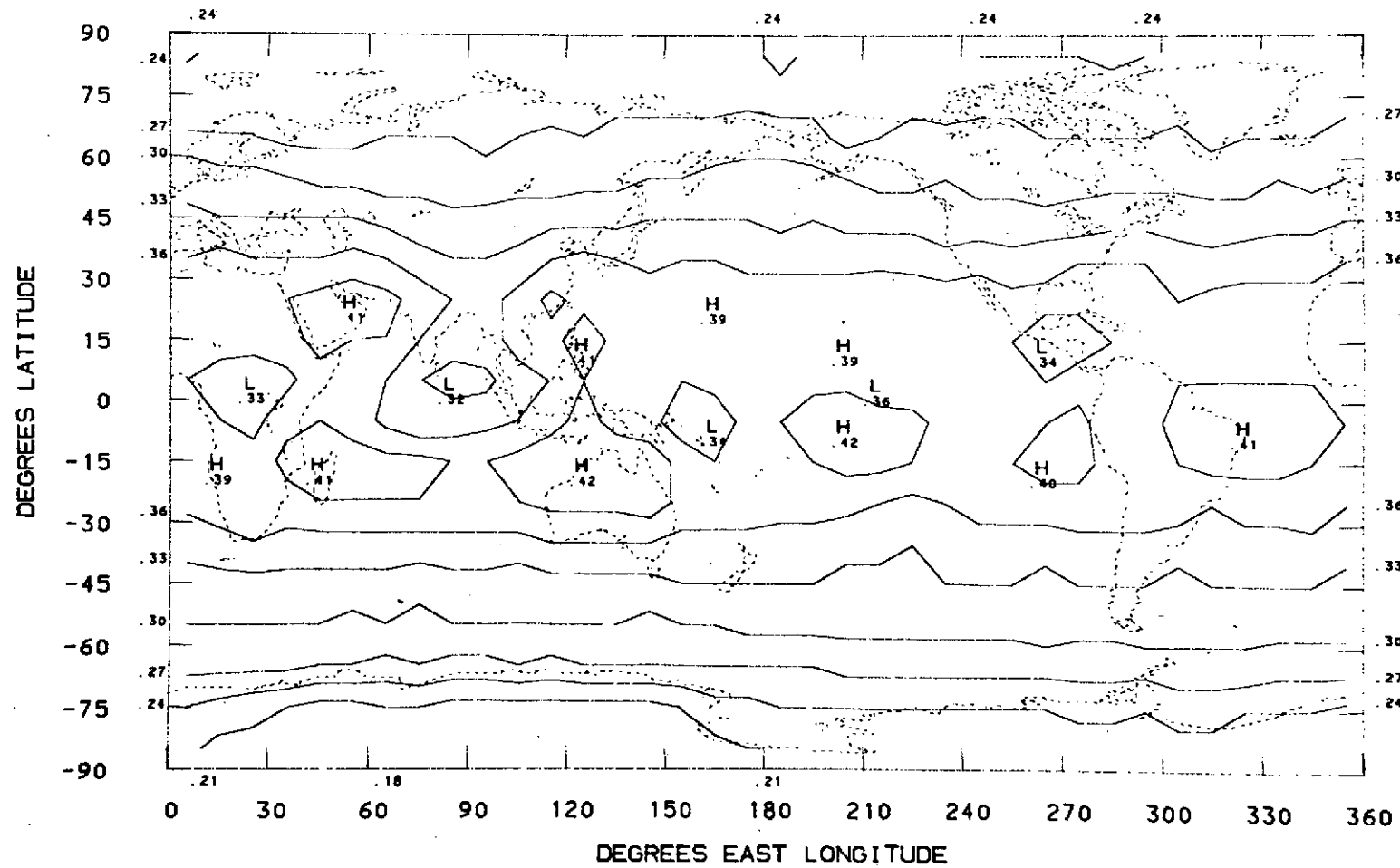


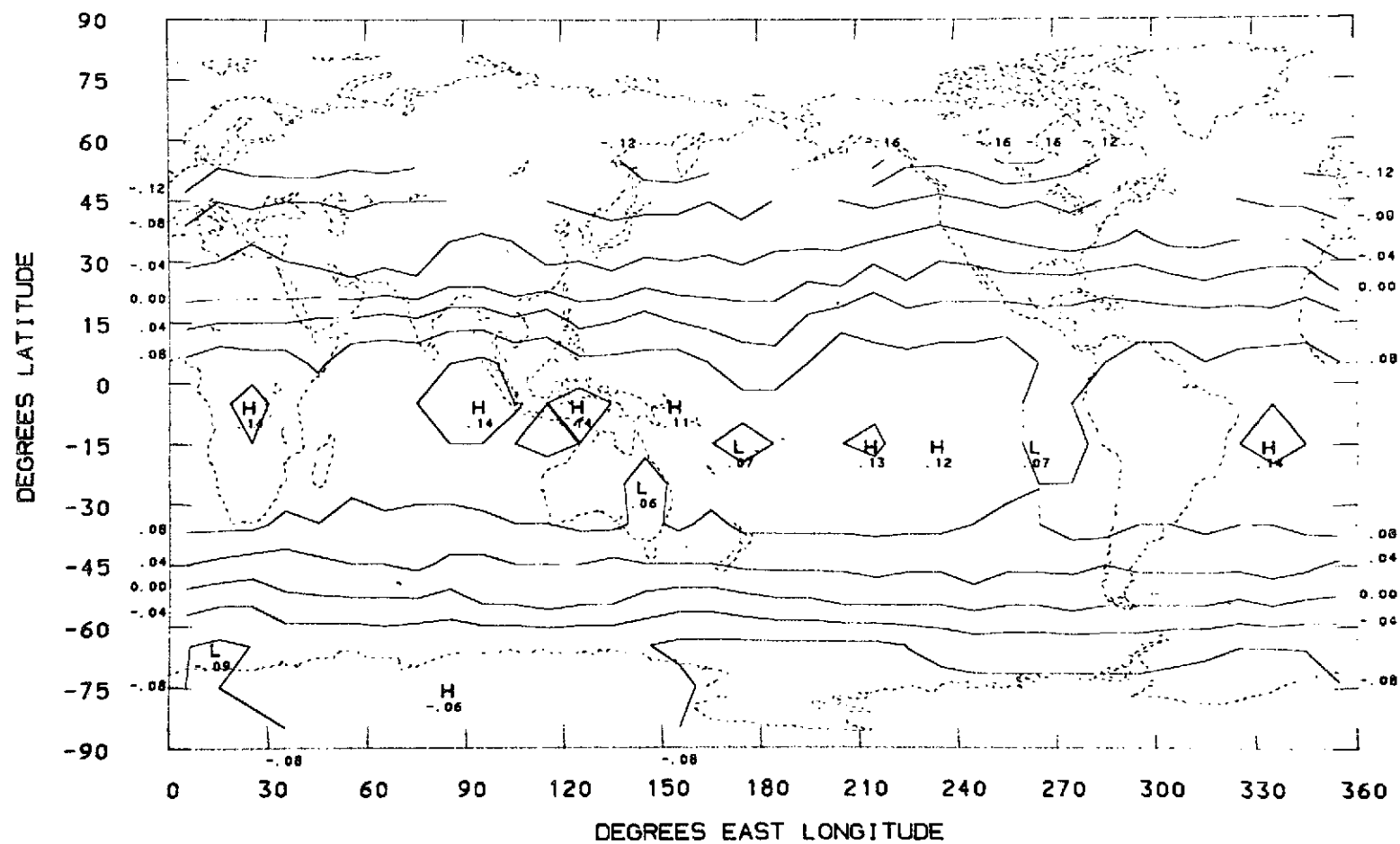
Figure 1 is a map of the Northern Hemisphere showing isobars and isotherms. The map covers latitudes from 90°N to 90°S and longitudes from 0° to 360°. Solid lines represent isobars (pressure in mb) and dashed lines represent isotherms (temperature in °C). Key features include a low-pressure system (L 27) over the North Atlantic, a high-pressure system (H 30) over the North Pacific, and a low-pressure system (L 15) over the South Pacific. Isotherms are labeled with values such as 30, 35, 40, 45, 50, 55, and 60.

Figure 1 is a map of the North Pacific showing the distribution of sea surface temperature (SST) anomalies. The map covers latitudes from 90°N to 90°S and longitudes from 0° to 360°. Contours represent SST anomalies in degrees Celsius, with solid lines for positive and dashed lines for negative values. Shaded regions indicate areas of statistical significance at the 95% level. The map shows a prominent positive anomaly in the central North Pacific, with negative anomalies in the North Atlantic and parts of the South Pacific.

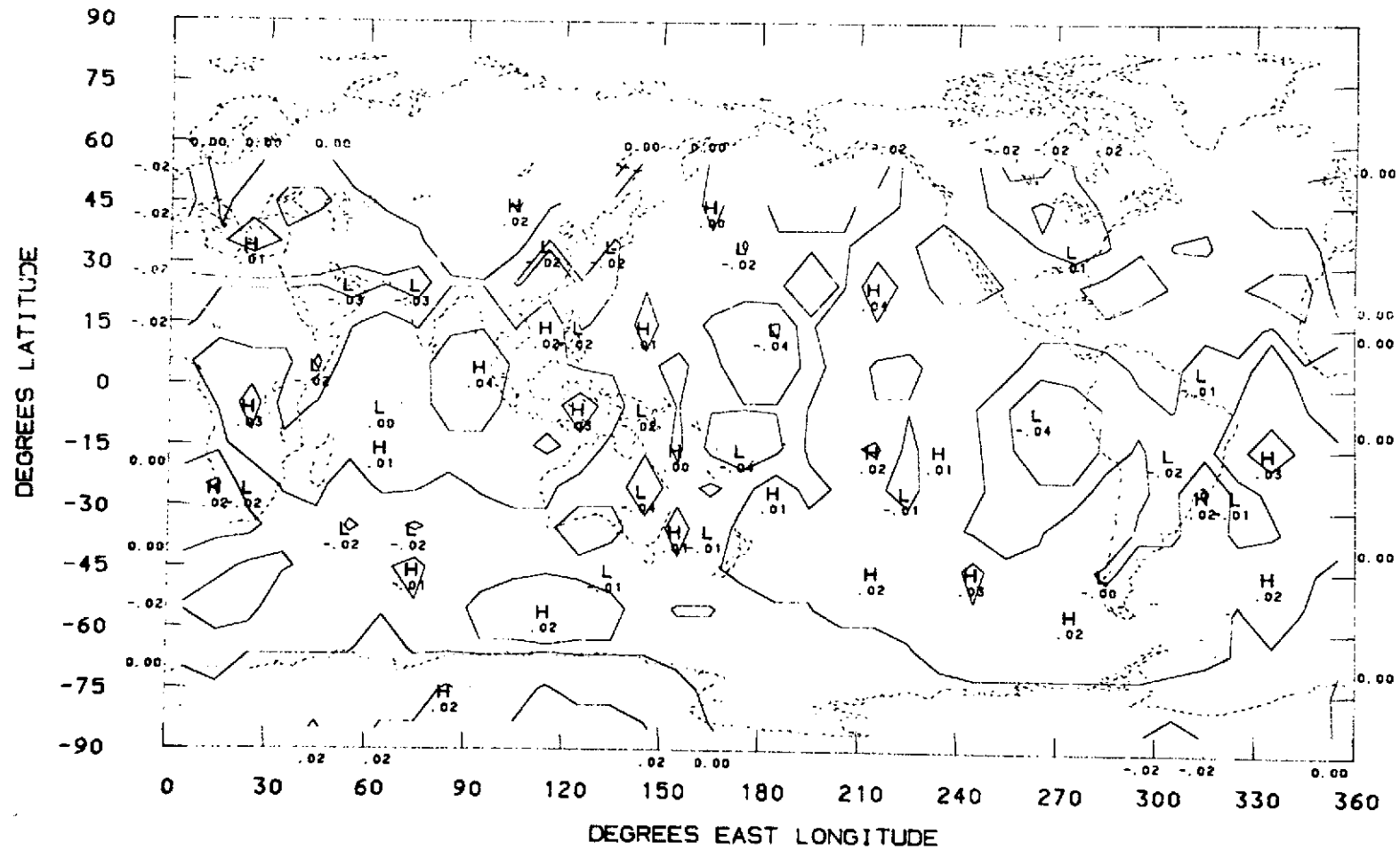
LONGWAVE RADIATION (LY/MIN)
MEAN SEP OCT NOV



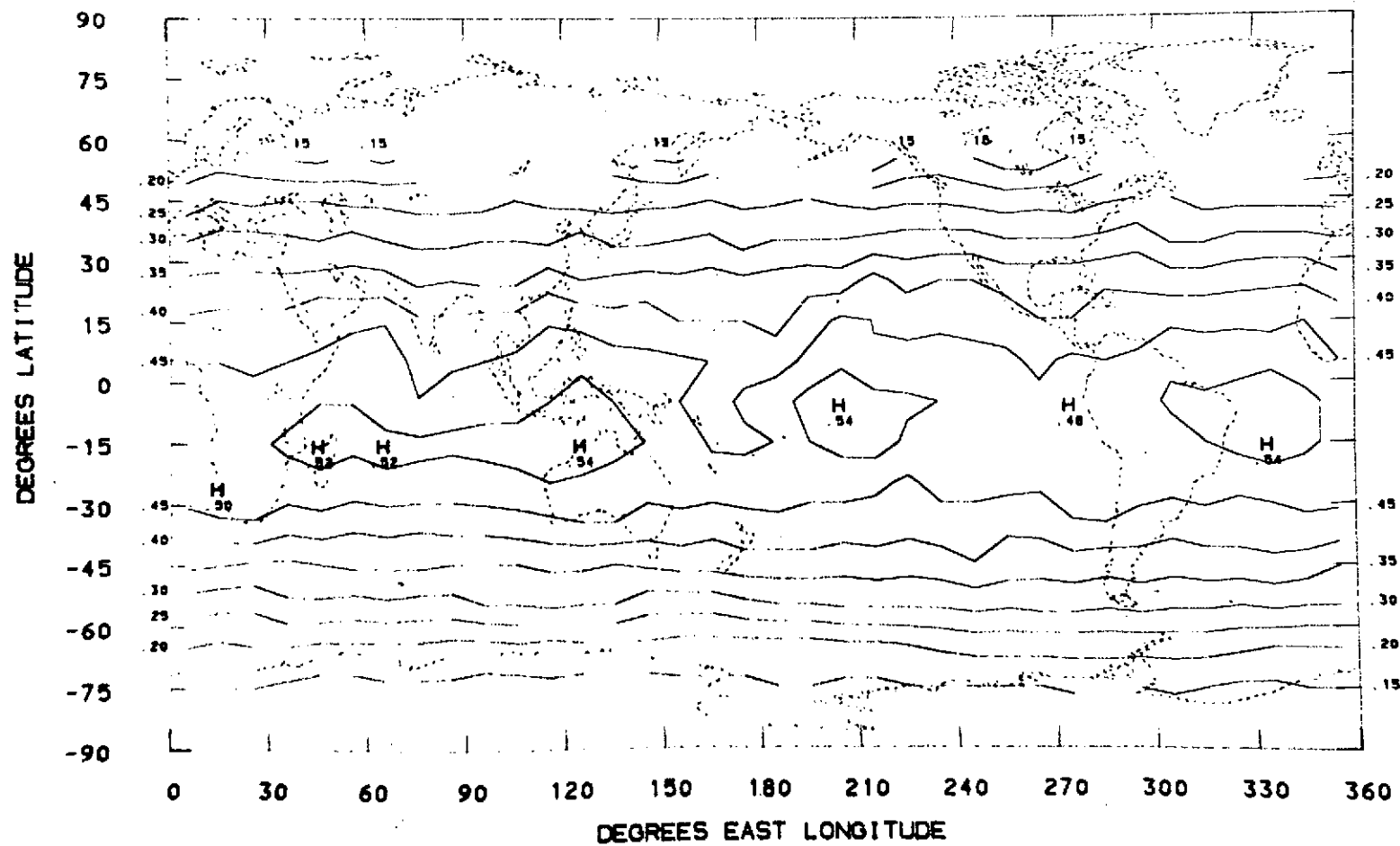
NET RADIATION (LY/MIN)
MEAN SEP OCT NOV



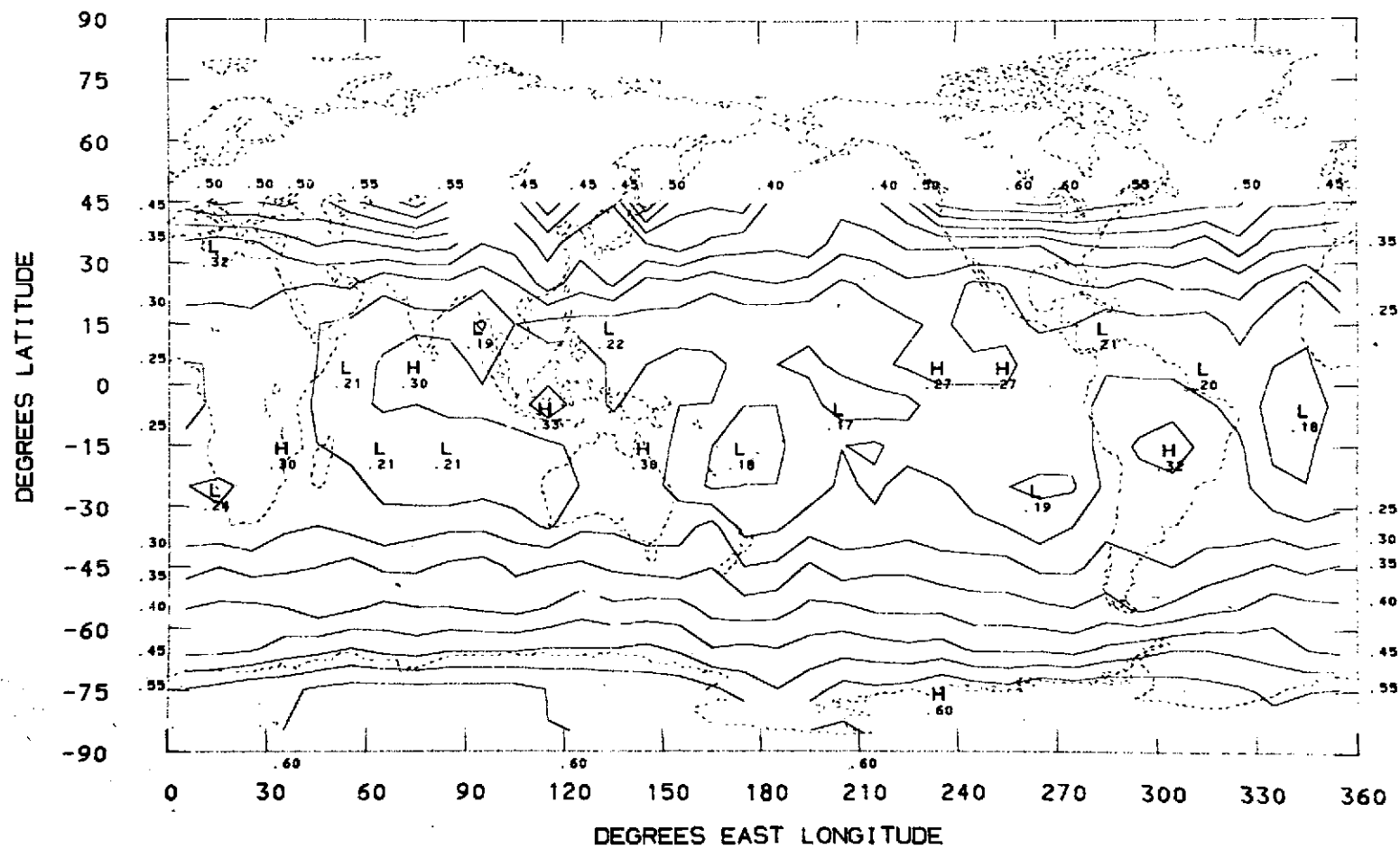
NET RADIATION (LY/MIN)
DEVIATION FROM ZONAL AVG. MEAN SEP OCT NOV



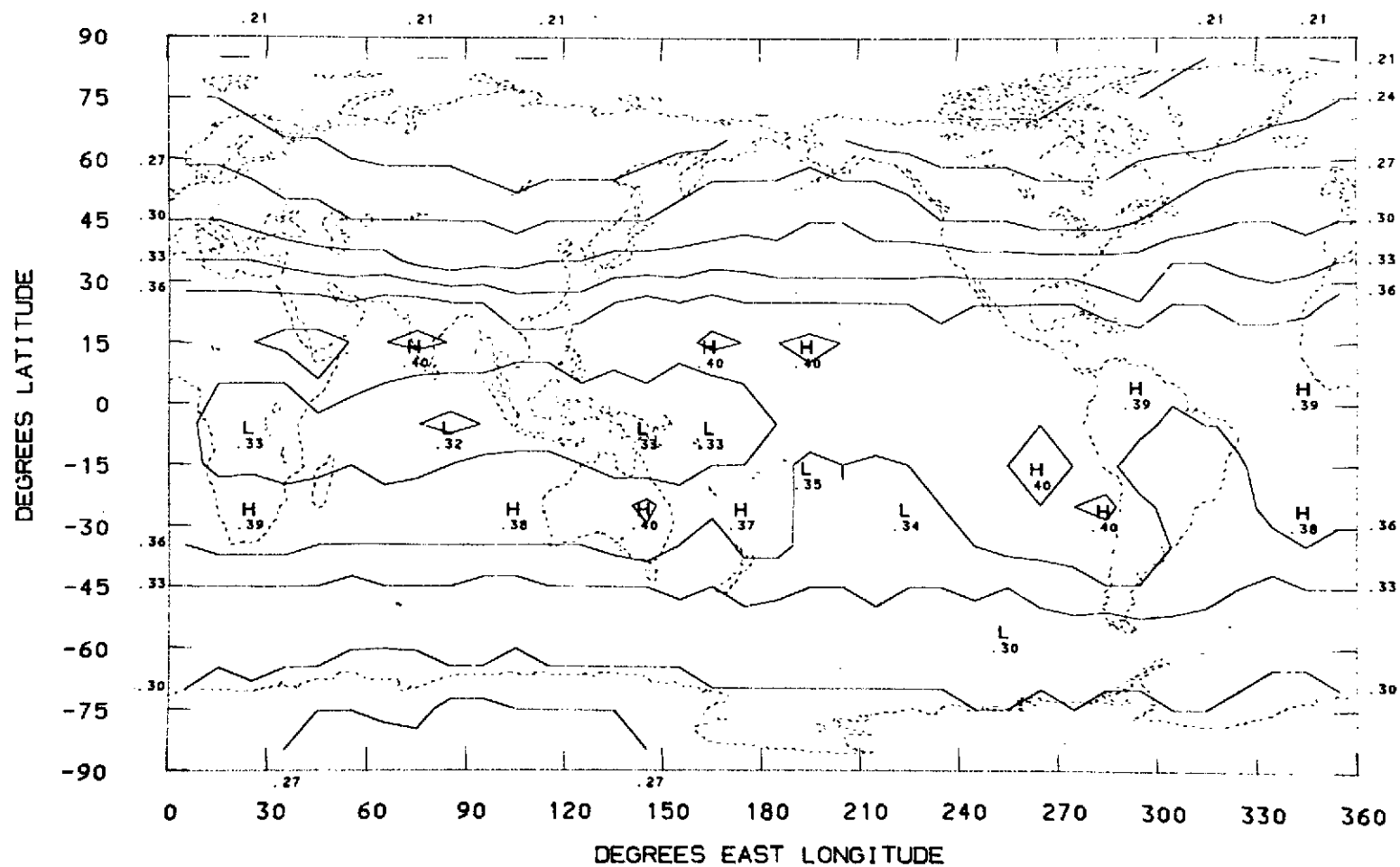
ABSORBED RADIATION (LY/MIN)
MEAN SEP OCT NOV



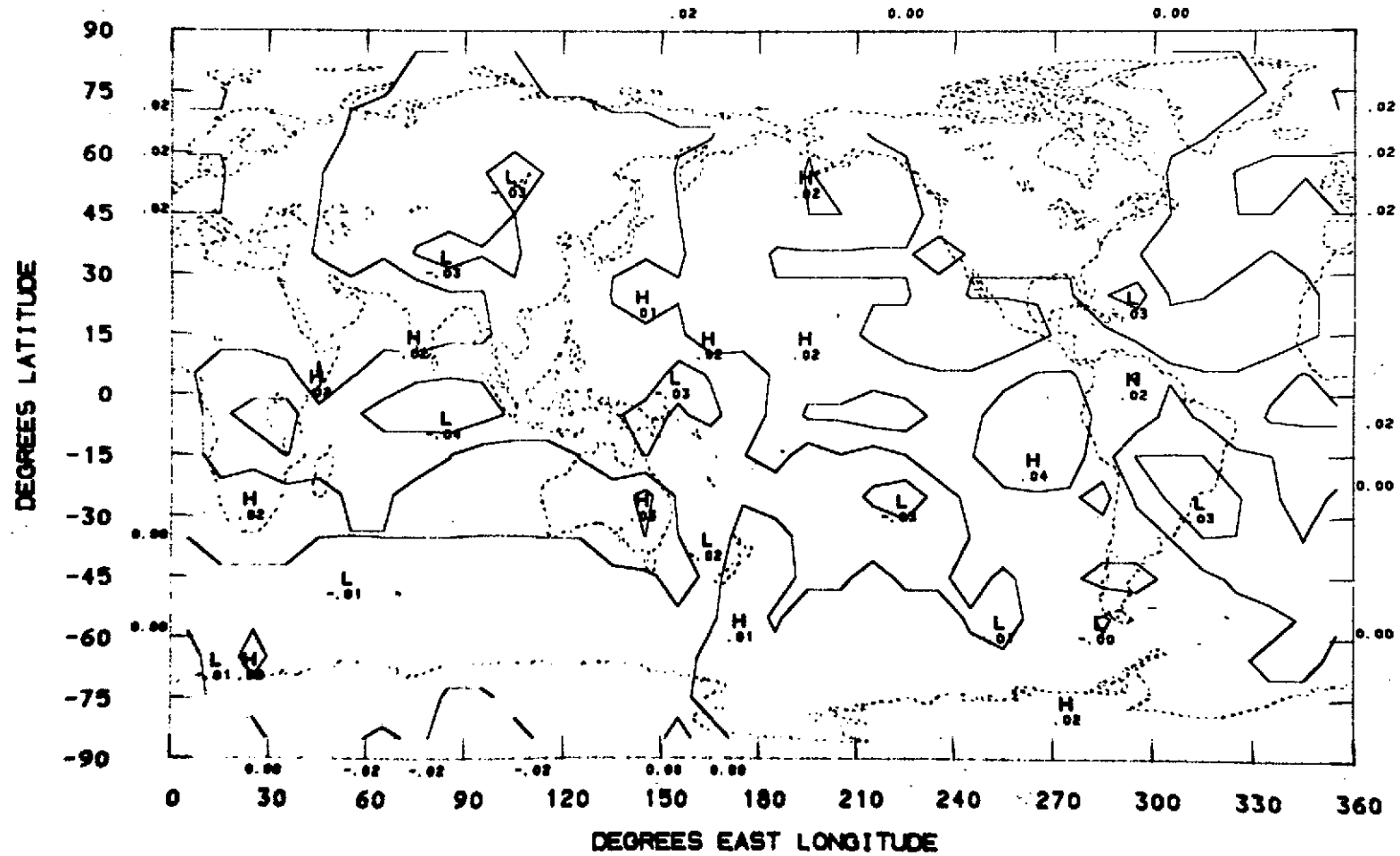
PLANETARY ALBEDO
MEAN DEC JAN FEB



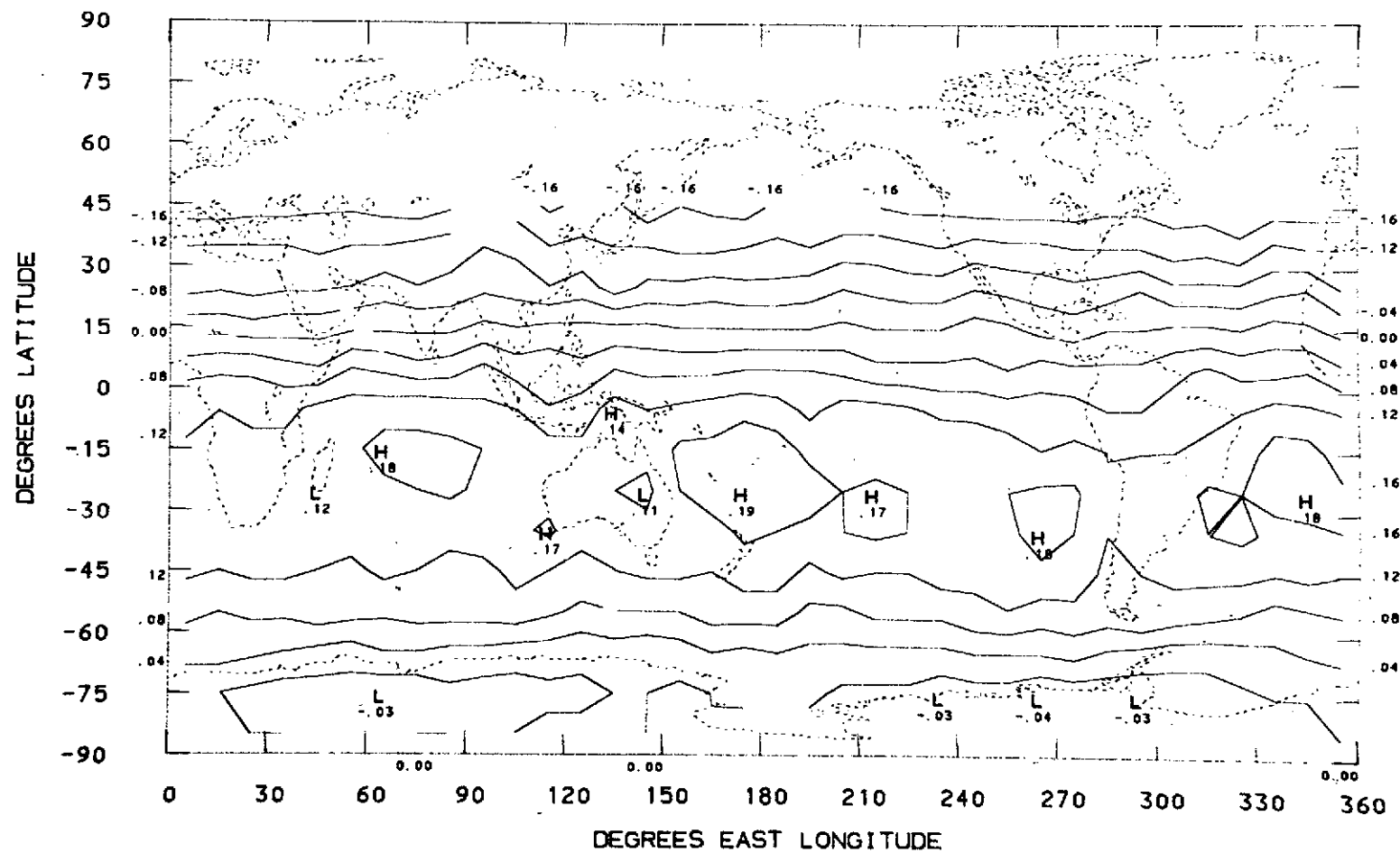
LONGWAVE RADIATION (LY/MIN)
MEAN DEC JAN FEB



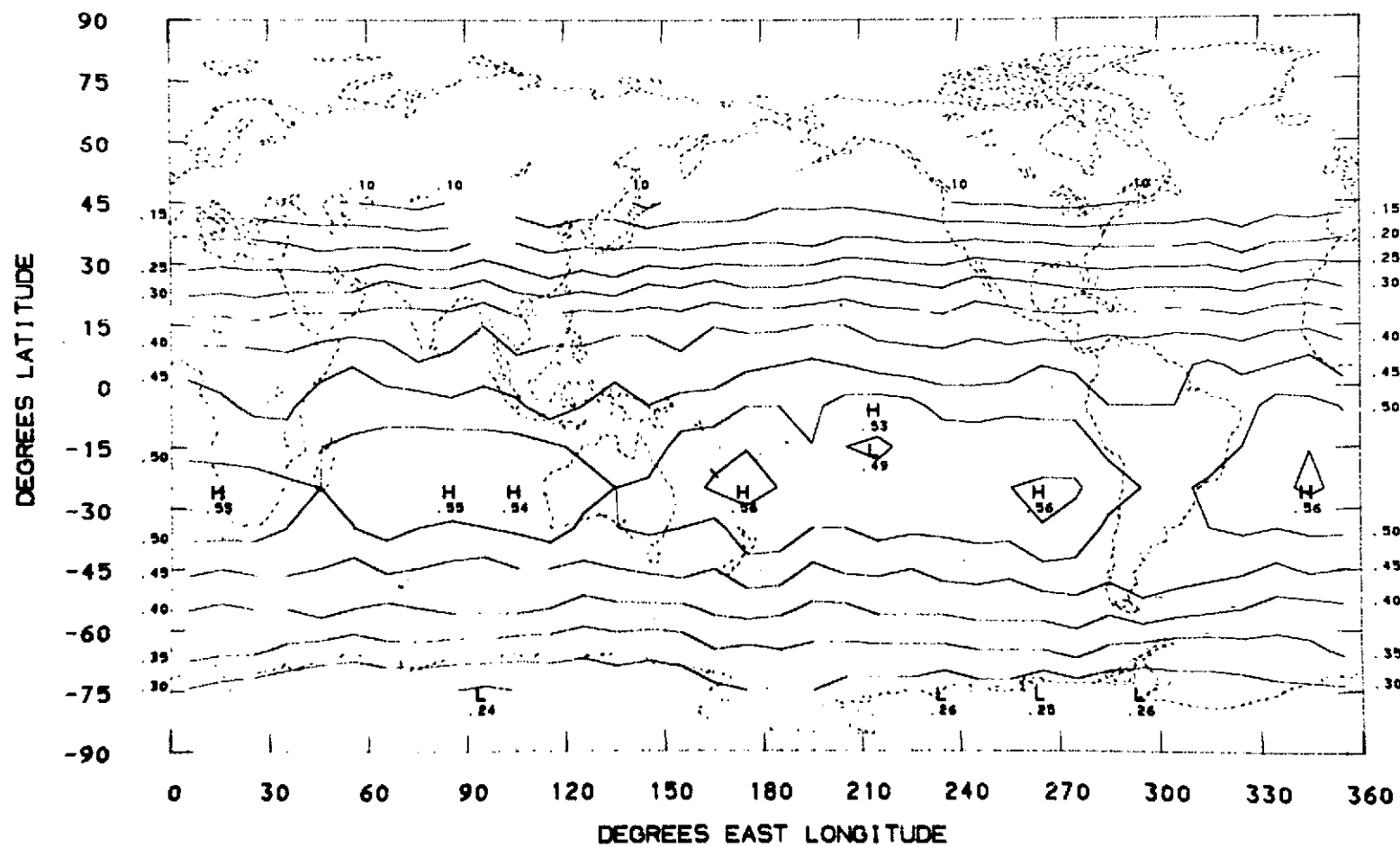
LONGWAVE RADIATION (LY/MIN)
DEVIATION FROM ZONAL AVG. MEAN DEC JAN FEB



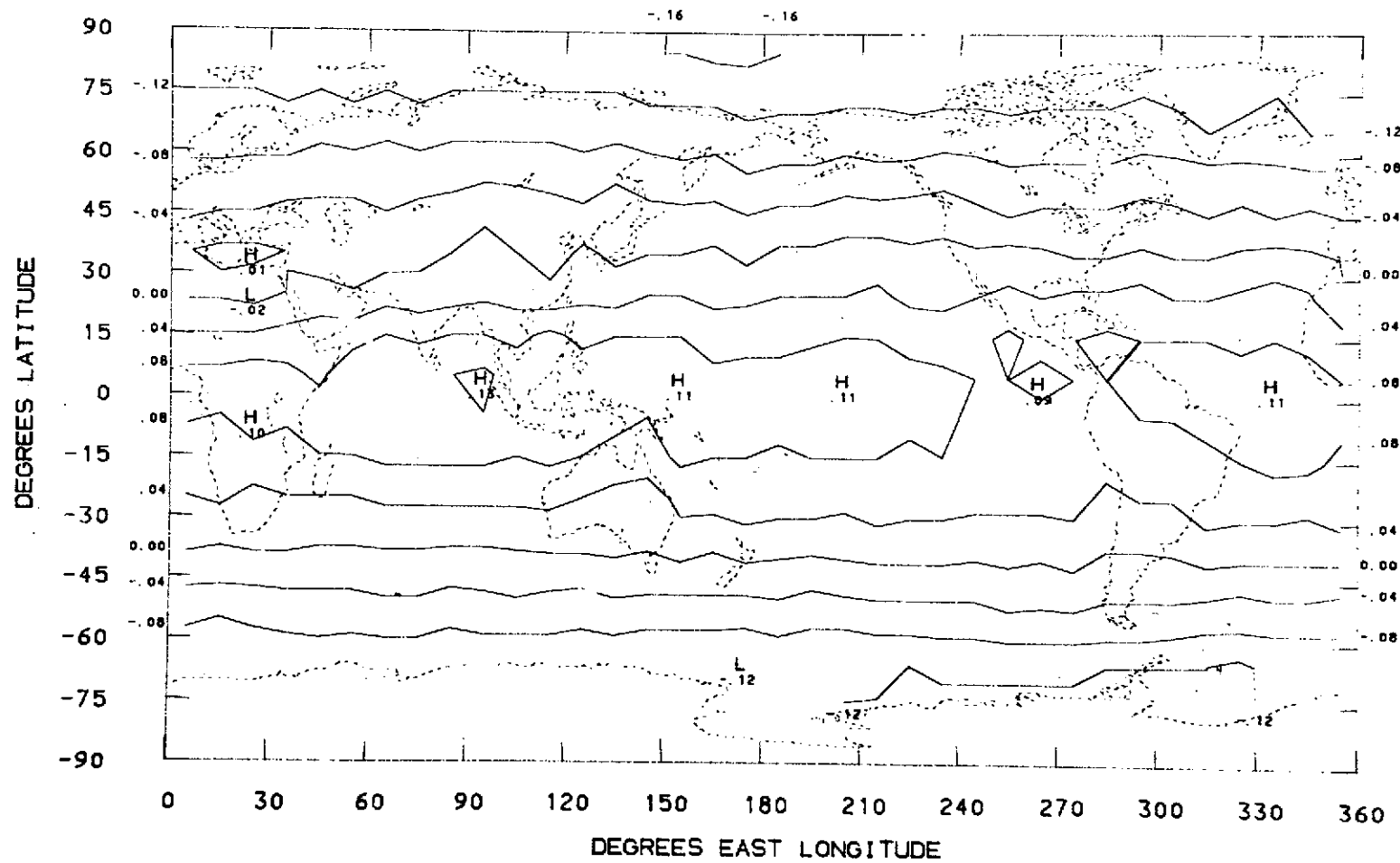
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MEAN DEC JAN FEB



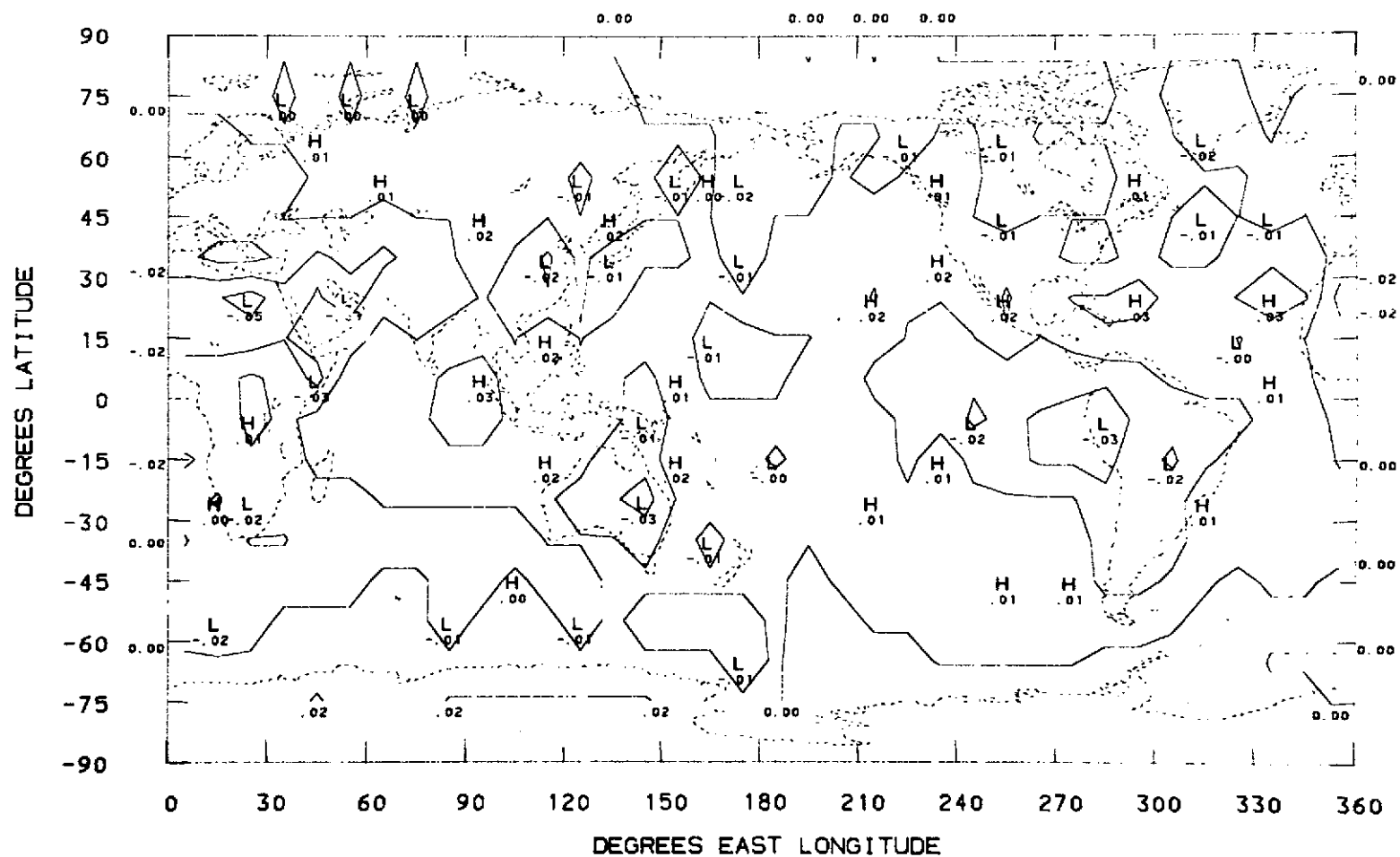
ABSORBED RADIATION (LY/MIN)
MEAN DEC JAN FEB



NET RADIATION (LY/MIN)
MEAN ANNUAL 1962-70 17 SEASONS



NET RADIATION (LY/MIN)
DEVIATION FROM ZONAL AVG. MEAN ANNUAL 1962-70 17 SEASONS



ABSORBED RADIATION (LY/MIN)
MEAN ANNUAL 1962-70 17 SEASONS

